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Opportunities and limitations for harvesting and processing Iceland scallops

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Preface

This study was carried out as a fisheries graduate p. iii
thesis by T. Venvik under the direction of assoc.prof. O. Vahl. The work is to a large extent financed by the Institute for Fisheries Trades , the University in Tromso, but is based on research started by Professor E. Brun, now deceased, and financed by the Norwegian Research Council. This work was carried on by O. Vahl with some financial assistance from the Norwegian Fisheries Research Council (project no. 1231.10). The investigations could not have been carried further without assistance from a number of people and businesses that have placed their knowledge and experience at our disposal. We therefore wish to thank biologist Solmundur Einarsson, the crew on the R/V "Drofn" and M/V "Grettir" and manager August Sigurdsson for their cooperation during a study tour of Stykkisholmur on Iceland, and especially the fisherman H. Olansen and the company H. Richardsen A/S who took the risk of carrying out trials with harvesting and producing scallops.

Introduction

Finds from ancient garbage dumps indicate that shellfish have been used for food by coastal inhabitants since the stone ages (R. Berthelsen, personal communication). Shellfish have also been used for bait as long as line fishing has been known (Throsvik 1977, Richardsen (note) 1978). There are no statistics over how large the harvest for bait could have been, but Richardsen (note 1978) indicates that about 2000 tonnes shell meats of various species could have been harvested per year. p. 1

However, the harvest is very low at the present time. In 1976, only ten tonnes of mussels were registered (table 2) and the use for bait has also declined sharply as other bait supplies have been made available.

The supply of traditional marine raw materials is now limited, and both fishermen and industry are forced to seek alternate resources. New knowledge of harvesting and production technology, new products and possible markets have created a new interest in utilizing shellfish resources (Gundersen (note) 1977, Jorgensen (note) 1978, Richardsen (note) 1978).

The shellfish species primarily promising for commercial utilization in Norway are mussels (Mytilus edulis), Giant Scallop (Pecten maximus), Iceland scallop (Chlamys Islandica), horse mussel (Modiolus modiolus), ocean quohaug (Arctica islandica), soft-shell clam (Mya arenaria, Mya truncata), cockles (Cardium edule), Lima species (Lima hians), and (Lima excavata), Venerupis species and razor clam (Ensis spp.). These species have a different distribution and stock structure (Wiborg and Bohle 1968), but it is assumed that considerable resources are

available. However, they have been poorly studied with respect to commercial utilization and it is therefore difficult to estimate possible yield. Mussels, horse mussels, Iceland scallops and ocean quahogs are probably of greatest interest since these species have the widest distribution and can occur in relatively large quantities (Wiborg and Bohle 1968). Mussels are well suited for cultivation (Bohle 1974). Cultivation of horse mussels, Iceland scallops and ocean quahogs has not been tried so that these species at the present time are only available in natural populations. Mussels, Iceland scallops and ocean quahogs are well-known and established products on the world markets, while new products must be developed and marketed from horse mussels.

Even if the shellfish harvest is not very important in Norway today, it is considerable on a world-wide basis. In 1976 p. 2 the total quantity was 2.43 million tonnes (table 1). This was about 3.5% of the total harvest of fish and shellfish in that year (FAO 1977). For comparison it can be mentioned that the total Norwegian capelin catch in the record year 1977 was about 2.1 million tonnes.

Table 1.

Harvest of shellfish distributed by groups (Anon. 1977)

Oyster - like species	900,000	tonnes round wt.
Clam and Mussel species	1,168,000	" "
Scallop species	360,000	" "
Total	2,428,000	tonnes round wt.

In the scallop group, most is comprised of the species Placopecten magellanicus (sea scallop, Giant scallop) harvested on the north-east coast of North America. The quality in 1976 was 168,000 tonnes and this was fairly evenly divided between USA and Canada. In Japan a total of 95,000 tonnes of the species Patinopecten yessoensis was landed, while 38,000 tonnes of the large scallop (Pecten maximus) was harvested in Europe. Otherwise, considerable quantities of calico scallops, Argopecten gibbus and Bay scallop, Argopecten irradians are landed on the east coast of the USA. Around the British Isles some Queens (Chlamys opercularis) and at New Zealand Pecten novazealandiae are harvested.

Table 2.
Shellfish harvest in some important nations (FAO 1977)

Japan	680,000 tonnes round weight
USA	640,000 " " "
South Korea	300,000 " " "
France	156,000 " " "
Spain	119,000 " " "
Canada	100,000 " " "
Netherlands	74,000 " " "
Great Britain	50,000 " " "
Denmark	37,000 " " "

Chlamys islandica (Iceland scallop) is a scallop species (Pectinidae) which in Norwegian is called "haneskjell", hesteskjell" or "sagskjell" (Wiborg 1963). Chlamys islandica will from now on

be called "haneskjell". The Iceland scallop resources along the Norwegian coast have earlier been used for bait. The extent of this exploitation is difficult to determine, but this shellfish could probably have comprised a considerable part of the total bait supply in Troms and Finnmark (see the "introduction").

There has also been a certain harvest of Iceland scallops for human consumption along the coast. In the early 1960's quantities of this shellfish were taken near Kvaenangen and delivered to H. Richardsen Ltd. in Tromso for processing. Some were also sent to Oslo by Jon Berg, Norddive. Towards the end of the 1960's some Iceland scallops were also processed at Br. Aarsaethers plants in Kjollefjord and Vadsö. Richardsen (note 1978) estimates total harvest in this period at ca. 500 tonnes. The main reason for stopping the fishery was poor viability for fishermen as well as processors. The reason for this can be that there were more poorly developed fishing and processing technologies in those days and that the market was poor for scallops of this size (Richardsen, personal communication).

Since that time it has become known that exploitation of Iceland scallops started on Iceland and that new fishing and processing methods were taken in use there (Gundersen (note) 1977). The harvest started in 1969 and reached a peak in 1972 with a total quantity of 7349 tonnes. The harvest was in subsequent years reduced to between 2.5 and 4 thousand tonnes. In 1978 the harvest is estimated to be about 5000 tonnes (August Sigurdsson, personal communication). In the past 10-15 years there has also been a fishery developed for other scallop species such as Queens Chlamys operularis, Calico scallops (Angopecten

irradiaus) and Bay scallops (Angopecten gibbus)(Broom 1977). These are species that are similar to the Iceland scallop and since fishing and processing of these species are profitable, it is of interest to investigate if it is economically possible to exploit the Iceland scallop resources in Norwegian waters.

From the studies of the Iceland scallop population at Berg in Balsfjord there is now a reasonable amount of background material available so that a sustainable long-term yield can be estimated (Claussen 1975, Petters[illegible] 1976, Vahl 1976, Vahl 1979, a,b). From this material there are data available on density, growth, recruitment, seasonal variations with respect to water content, dry matter and contents of protein, fat and carbohydrates. Taken together, this information forms a good basis for discussing a harvesting strategy for the grounds. On the assumption that recruitment and growth of Iceland scallop is essentially not different in other populations, this information could also form the basis for evaluating other grounds. It is therefore of interest to carry out a collective evaluation of the opportunities for utilizing the scallop resources and how harvesting and processing technology is to be adapted for Norwegian conditions. Such an evaluation will have four main aspects:

p. 4

Aspect 1

A general evaluation of the biology of Iceland scallops, especially with respect to distribution, density, food uptake, propagation and growth. On a background of this information, it can be indicated which long-term sustainable yield the Iceland scallop resources can give.

Aspect 2.

A study of possible harvesting techniques and an evaluation of arrangement, equipment and organization onboard the vessel.

Aspect 3.

An evaluation of possible products and processing technologies.

Aspect 4.

An economic evaluation of markets, price levels, and costs.

I. Biology

Iceland scallop (fig 1) has a subarctic or northerly boreal distribution. The shellfish occur around the North Pole from the White Sea, along the Murman coast, Norwegian Coast and over towards Hopen, Spitzbergen, Jan Mayen and Iceland. There are also reported occurrences in Bering Strait, along the coast of Alaska, in the Bering Sea, the Okhotsk Sea and the Kara Sea (Wiborg 1963).

The largest concentrations in Norwegian waters are at Bear Island and Spitzbergen (Wiborg 1970, Wiborg et. al 1974). Iceland scallops are found primarily to the north of Lofoten, but there are also isolated populations further south, such as in Beiarn (Wiborg and Bohle 1968). The most southerly concentration known is found in Fanskangerpollen near Bergen. This population is, however, a relic from a colder period, and very special temperature conditions in the "poll" (a small fjord with narrow inlet) has contributed to the survival of the population.

North of Lofoten several concentrations are known today

and Wiborg (1963) lists the following:

1. The Balsfjord grounds. Scallops can here be found over a larger area at a depth from 25 to 60 metres. The bottom is smooth and well suited for fishing, but there are quite a few rocks.

2. The Adams Fjord. These grounds are relatively small and poorly suited for raking. The scallops are, however, large and of good quality.

3. In Ulls Fjord. Inside a sill of about 10 metres, scallops can be found on smooth sandy bottom from 40 to 60 metres depth.

4. The Kvaenang grounds. At the inner end of Kvaenangen there is a small concentration at 25 to 40 metres depth.

5. The Porsanger grounds. This is the same size as the Balsfjord grounds and is located in Osterbotn in Porsanger. There are really several small concentrations here. The scallops are found chiefly from 40 to 60 metres, but heavy concentrations have been found up to 20 metres depth.

6. In Kongsfjord. In the inner part there is a small concentration with large and fine scallops.

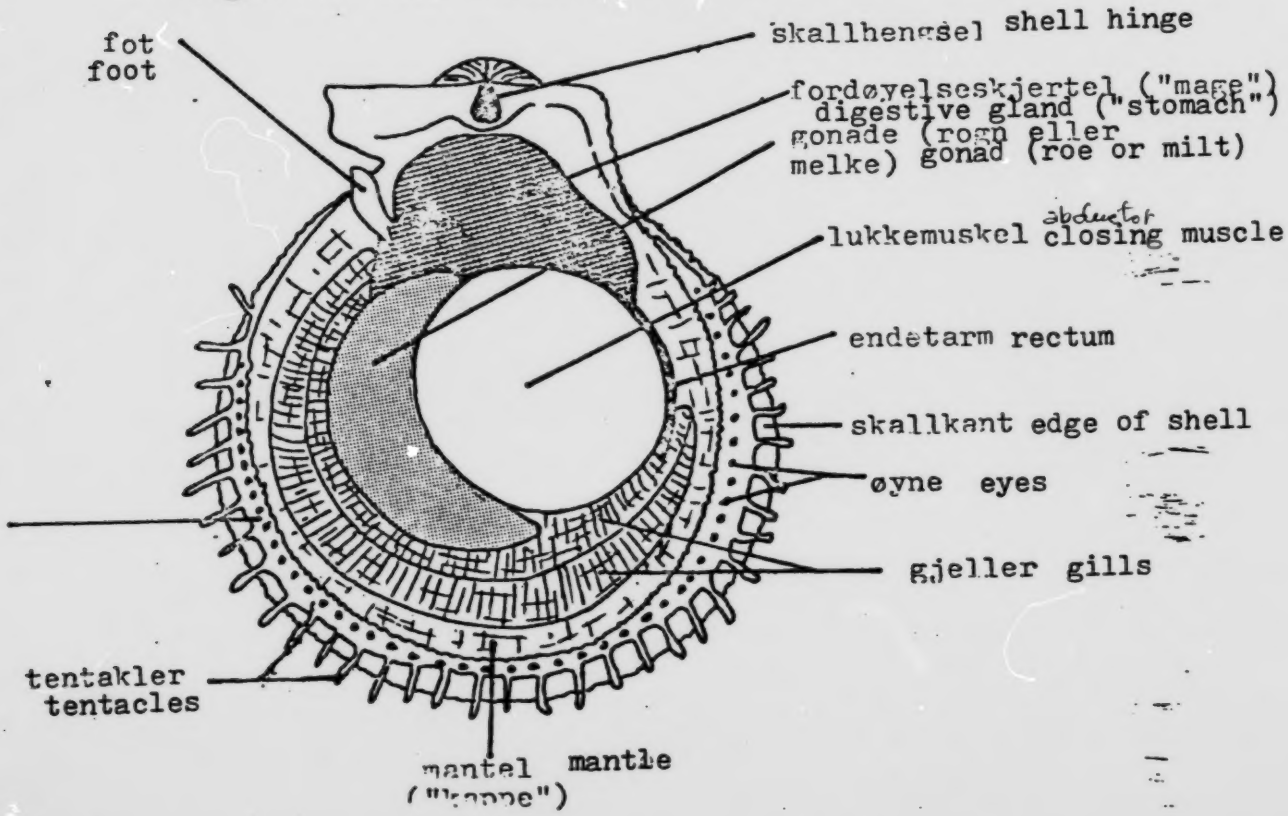
7. In the Neide Fjord. There are several small concentrations at 10 to 20 metres depth.

It is also possible that there are concentrations other than these and that the grounds now have a different character and structure than found by Wiborg (1963). On the Kvaenang grounds only small quantities were found in fishing trials in the summer of 1978, while this area yielded considerable catches in the beginning of the 1960's (page 3). The Balsfjord

Figur 1. Shell of Iceland Scallop.

Skall av haneskjell.
Årringene er merket med piler.
(foto K. Hansen)
The year-rings are indicated with arrows. (photo K. Hansen).

Figure 2. Soft tissue of Iceland Scallops. Left shell removed.



Figur 2. Bløtdeler av haneskjell. Venstre skall fjernet

concentrations now seem to be more concentrated on the areas near Berg, and in fishing trials in the summer of 1975, only small quantities were found in the positions mentioned by Wiborg in 1963 (Gulliksen, personal communic).

Environmental requirements

Iceland Scallops are chiefly found on bottoms with sand, gravel, shells and sometimes clay (Wiborg 1963). The shell is always fastened to the substrate with byssels (Claussen 1975). Iceland scallops are therefore found in greatest density on relatively coarse substrates with gravel, small rocks or shell gravel. On the grounds at Berg in Balsfjord there are moraine ridges that have been washed clean by the current, and such bottom conditions form a good base for scallops (Pettersen 1976). Scallops are found at depths between 10 and 250 metres. Along the Norwegian coast the depths are commonly from 15 to 60 metres (Wiborg 1963), while at Bear Island scallops are most plentiful in 80 to 100 metres depths and at Spitzbergen from 40 to 55 metres depth (Wiborg et. al 1974).

Along the Norwegian coast scallops are most often found in fjords of relatively low salinity (Pettersen 1975). Since they also occur in saltier Atlantic Ocean water, it can hardly be assumed that low salinity is a pre-condition for the occurrence of scallops. The salinity at Berg varies between 22.5 and 33.8 per mille (Pettersen 1975). At Jan Mayen and Bear Island where there are relatively large concentrations, the salinity can reach 34.9 per mille (Wiborg 1963).

Nutrition and Growth

The large gills on the Icelandic scallops are covered with fine hair that beat with a frequency of 1-2 beats per second. Water is thereby pumped through the shell. The food is organic particles suspended in the water, filtered from the water when passing through the gills. The scallop is dependent on getting food particles with the current and is therefore most numerous in areas with strong currents. (Wiborg 1963). What the food consists of is not fully known, but it must be assumed that phytoplankton comprises a considerable part. Detritus (parts of dead plants and animals) also probably play a certain role. Vahl (1973) demonstrated that Iceland scallops filter effectively down to a particle size of 0.007 mm.

Seasonal variations in growth can be seen in growth zones in the shell (fig. 1) and these form the basis for age determinations and measurements of the earlier years' growth (Wiborg 1963). Growth curves for the populations in Andamsfjord, Korsfjord in Neiden and Kvaenangen are calculated from measurements of shell-width and age determinations. Growth measurements on the Berg grounds show that most of the annual growth occurs in April-June (Claussen 1975, Pettersen 1976). The measurements agree well, but it appears as if the growth on the Berg grounds were somewhat faster than on the other grounds. The growth at Berg is most rapid up to age 6-7 years when the shells are about 65 mm wide. In the Andams Fjord the growth seems to be good up to age 10 when the shells are up to 85 mm across.

All these studies measure growth as an increase in shell width. The growth of soft tissue seems to be much more uneven with large variations throughout the year and between different grounds. Wiborg (1962) and Wiborg et al. (1974) showed that the weight of muscle is greater relative to shell size on the grounds in the Andams Fjord and at Bear Island than on other grounds. The annual variations in dry weight of the soft tissues also indicate that growth of these does not follow the growth of the shell (Sundet 1979). p. 9

Vahl (1979 a,b) felt that the supply of energy does not limit growth. There are sufficient nutrients and the quality is good enough for the scallop to grow all year (Sundet 1979). The reason for the large seasonal variations in shell and soft tissue growth must therefore be explained some other way. Vahl (1979 a) showed that at least 30% of total filtered particulate material must be of organic origin in order for the animal to grow. This is the case for only five months of the year (Vahl 1979a), and this is likely the most important growth-limiting factor for Iceland scallops. It is in this connection reasonable to assume that the quantities of unorganic particulate materials are greater on the bottom than in the upper water masses. Experiments in Scotland have shown that Queens (Chlamys operularis) have greater growth when raised from the bottom than on the bottom (J. Wallace, personal communication).

Reproduction

Iceland scallops become sexually mature at three to five years of age (Vahl 1979 a). The size is then from 35

to 45 mm. Animals with shell sizes larger than 50 mm are all sexually mature (Wiborg 1963). Spawning occurs in June/July, first in the shallower areas and somewhat later in greater depths (Pettersen 1976). The number of eggs is very large, and preliminary estimates on the grounds at Berg show that 76 million eggs per m^2 are spawned.

Vahl (1979 b) assumes that the recruitment is uneven and that the grounds are mainly recruited from shell that are two to five years old. Samples taken by diving in the summer of 1978 (see fig. 10) confirm this in that there were considerably larger numbers of shells in the size ranges 15 to 30 mm, but few one-year-old shells. The most scallops are, however, of a size range of 65 to 80 mm. This can indicate that scallops reach bottom at other places and later migrate to the grounds. Vahl and Claussen (1979) showed that Iceland scallops move on p. 10 an average every 31 days, and this shows that there is a large migration on the various grounds throughout the year. It can in this connection be mentioned that on a cruise with R/V Drofn in the summer of 1978 to Breidafjord on Iceland, it was observed that an area that had been fished (empty) one year earlier (Solmundur Einarsson, personal communication) now yielded good catch rates of large scallops. These could not have grown up on this ground and must therefore have migrated in from other areas.

Condition

The soft tissue of Iceland scallops consist of muscle, gonads (roe and milt), gills, digestive gland and mantle (fig. 2). The annual variations in total dry weight of the soft tissue

of scallops from Berg are large (fig. 3). The dry weight comprises ca. 17% of wet weight (Sundet 1979). It is not known if the same applies to Iceland scallops from other grounds, but it can be assumed that the variations throughout the year are similar. The gonads grow rapidly before spawning and then decrease after the spawning in June. The muscle weight increases rapidly in the summer but decreases during fall and winter.

Yield

The differences in yield by different harvesting strategies are large (fig. 4). If harvesting is not selective, the maximum yield could be about five grams dry weight of soft tissue per m^2 per year. By this harvesting strategy, the sustainable yield will decline when the catch effort exceeds a fishing pressure of 0.25.

Johannesen (manuscript) discussed at which age the harvest of Iceland scallop should be started. He proposed a minimum shell diameter of 63 mm, when the scallops are about 6 years old. From product considerations (page 33) it is assumed that the scallops can be harvested from the time they are seven years old. The shell diameter is then about 65 mm. With this exploitation pattern, the population could not be overexploited biologically (fig. 4). How high the harvesting rate is thus becomes a question of costs. The yield increases little when the p. 13 fishing pressure is higher than 0.5 (fig. 4). In later discussions this level is therefore assumed.

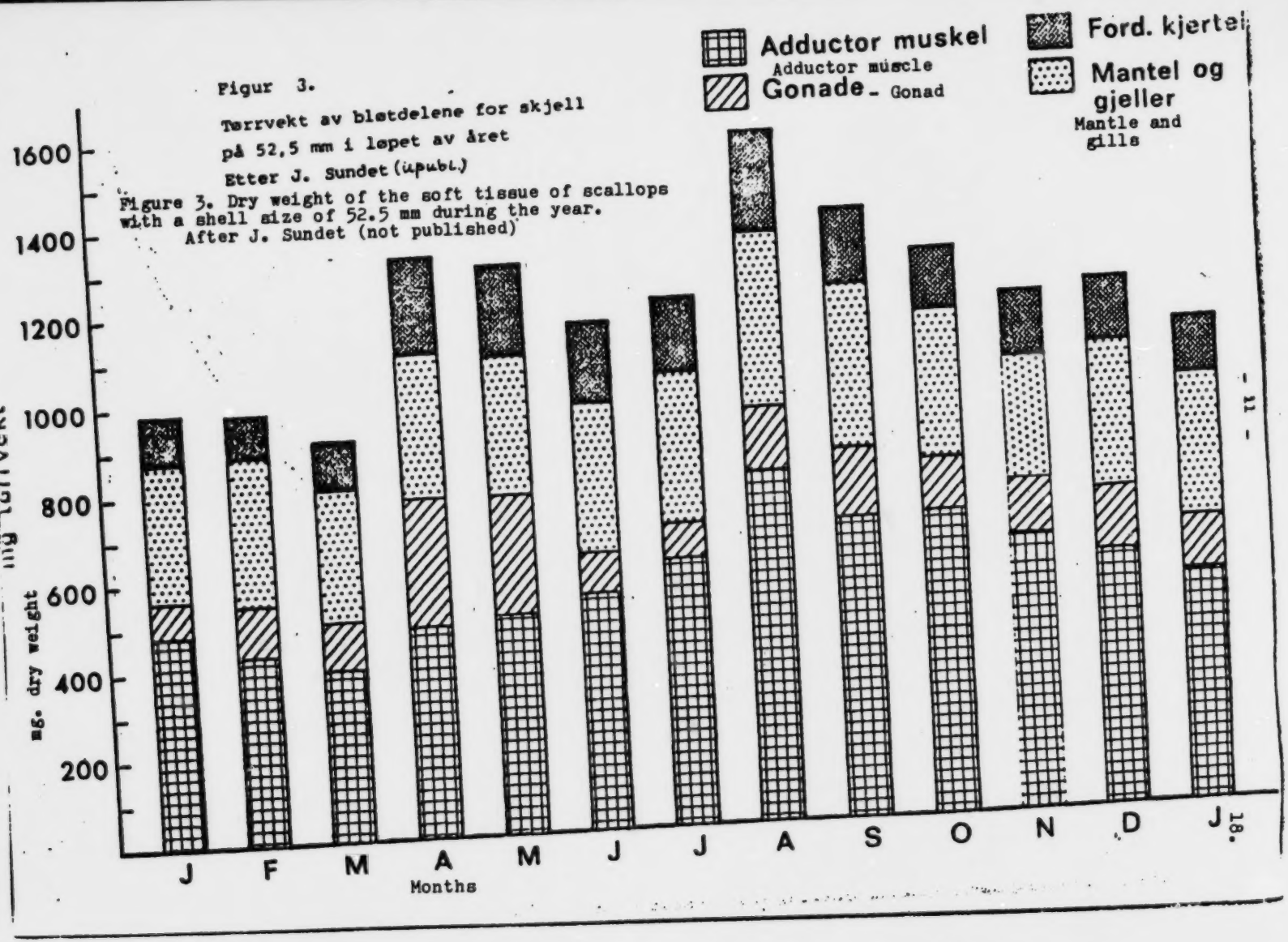
If the minimum size and the harvesting rate proposed above are chosen and fishing is carried out the whole year, about 11.6

Figur 3.

Tørrvekt av bløtdelene for skjell på 52,5 mm i løpet av året

Etter J. Sundet (upubl.)

Figure 3. Dry weight of the soft tissue of scallops with a shell size of 52.5 mm during the year. After J. Sundet (not published)



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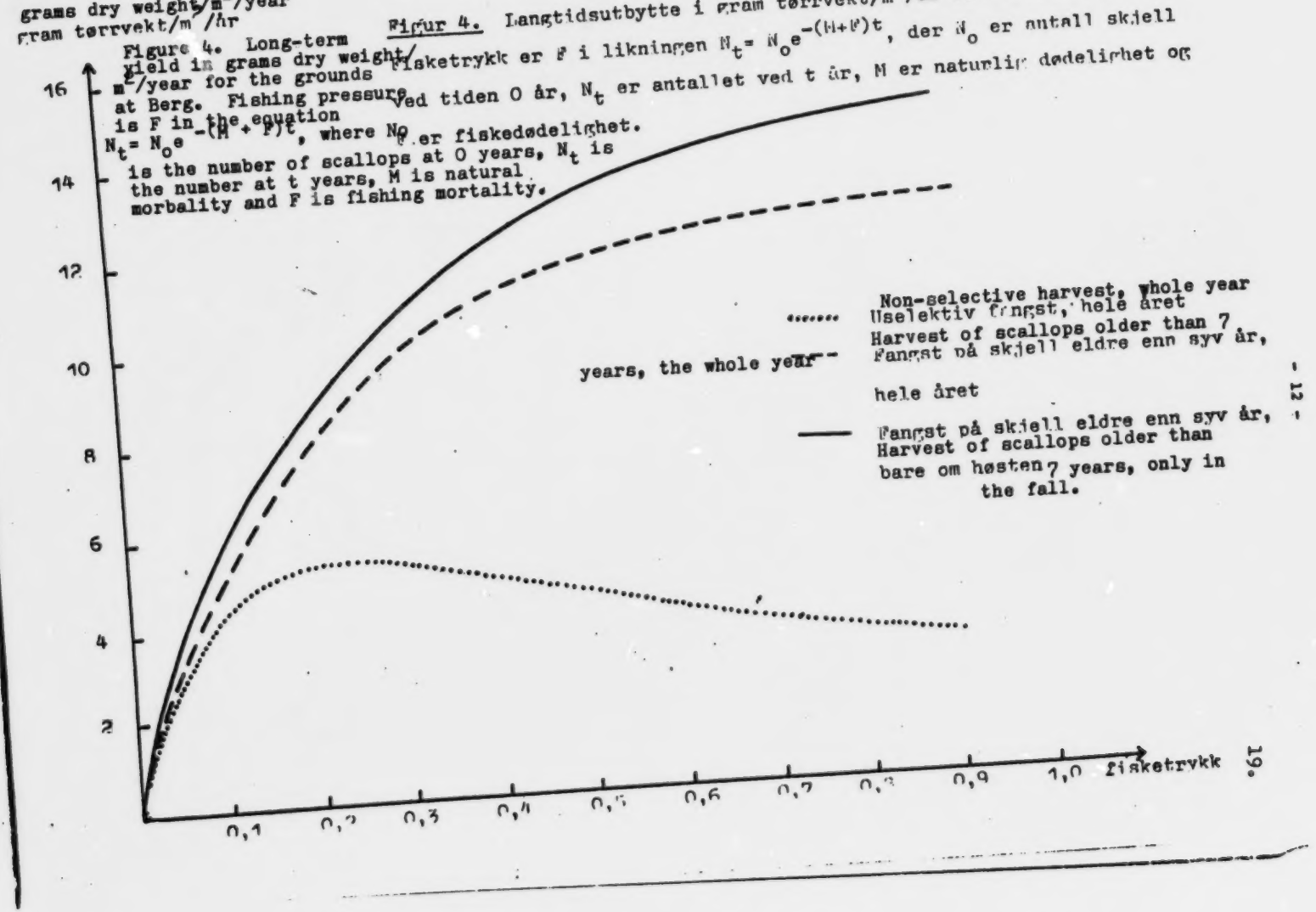


Figure 4. Long-term yield in grams dry weight/m^2/year for the grounds at Berg. Fishing pressure is F in the equation $N_t = N_o e^{-(M+F)t}$, where N_o is the number of scallops at 0 years, N_t is the number at t years, M is natural morbality and F is fishing mortality.

Figur 4. Langtidsutbytte i gram tørrvekt/m^2/år for feltet ved Berg. Fisketrykk er F i likningen $N_t = N_o e^{-(M+F)t}$, der N_o er antall skjell ved tiden 0 år, N_t er antallet ved t år, M er naturlig dødelighet og F er fiskedødelighet.

soft tissue dry weight could be harvested per m^2 per year. If the same minimum size and effort is retained, but all harvesting is carried out in the fall, the harvest of dry weight of soft tissue per m^2 per year would be 12.9 grams (fig. 4). In the fall the muscle comprises the largest part of total dry matter (fig. 3) so that the product yield is also highest then.

The data are available in grams of dry weight per m^2 per year. In order to calculate total yield in wet weight of soft tissue, the following formula can be used:

A x V x K x SY where

A = area, for example in km^2

V = conversion factor from gram to desired weight unit, for example tonnes.

K = conversion factor from dry weight to wet weight

SY = long term yield in grams per m^2 per year for the fishing pressure used.

On the Berg fishing grounds, if harvesting is only carried out in the fall and only scallop with a shell size larger than 65 mm is taken, the maximum long term yield per km^2 will be:

$10^6 \times 10^{-6} \times \frac{100}{17} \times 12.9 =$ <u>75.88 tonnes meat per year</u>.

The soft tissue comprises in this period about 17% of round weight (table 5). The yield in round weight is therefore:

$75.88 \text{ tonnes} \times \frac{100}{17} =$ <u>446 tonnes</u>

Since the muscle comprises 12% of round weight (table 5), the yield of muscle will be: $446 \text{ tonnes} \times \frac{12}{100} =$ <u>53.56 tonnes</u>

The whole Balsfjord ground is between 8 and 10 km^2. p. 14
The Berg ground, where the growth is as in the example above, is ca. 1 km^2. Since the catch rates on the rest of the ground is lower (table 4), one can hardly count on the same growth here. Possible long term yield for the Balsfjord ground can therefore be estimated to be between 500 and 1000 tonnes round weight per year.

According to Broom (1976), the Bay Scallop (Argopecten gibbus) is among the most productive scallop species. At the Niantic River the harvest is 300 lbs wet weight of soft tissue per year and per acre. (This corresponds to 336 kg per hectare (1 hectare = 10,000 m^2)). For comparison, Iceland scallops at Berg in Balsfjord will yield (12.9 x 10,000)/ 0.17 x 1000) = 759 kg per hectare if the dry weight of the soft tissue is estimated to be 17% of the wet weight.

II. Harvest of Iceland Scallop

The time and framework for the present study did not permit extensive gear testing or experimental fishing. The following discussions must therefore be based on fishing methods in use in other areas.

Various types of rakes have been used. Wiborg (1962, 1963, 1970 and Wiborg et al. 1974) describe rake types that were tested during experimental fishing along the coast of Northern Norway and at Bear Island and Spitsbergen. One of these was a British mussel rake called the "Baird Rake" (fig. 6). Since a rake like this could be found in Tromso, it was decided to base the experiments on this rake. Figure 7 shows a commercial

scallop rake from Shetland which was used for experimental fishing at Bear Island and Spitsbergen. This was also evaluated but found to be too large and not suitable for the vessel available for the trials. Other rake types have been described by Mason (1972), Hughes (1972, 1973), Rolfe (1973) and Broom (1976).

There is a fleet of shrimp trawlers along the coast of Northern Norway considered suitable for dragging gear. They have a considerable amount of the technical equipment necessary for raking and would only need a minor conversion. It is also assumed that the experience the shipper and crew have from shrimp trawling could be of use in scallop raking. Since the profitability for the coastal shrimp trawlers in Northern Norway is low (Anon. 1975), an alternative activity could be valuable. It is therefore assumed that scallop raking can be carried out by this fleet. p. 15

Experimental fishing

For all testing of gear and equipment, the University research vessel R/V "Ottar" was used. This is a wooden vessel of 50' with traditional hull form but with a somewhat special superstructure and deck arrangement. The vessel is equipped for trawling and most simple biological and hydrographic sampling. The trawl rigging was different from traditional shrimp trawlers of the same size in that it had one gallow on each side. All superstructure with the exception of engine and exhaust casing was placed forwards. The deck space was limited due to large superstructure and much technical equipment on deck.

A total of ten cruises were carried out with "Ottar". Eight of these were day cruises to the Berg/Balsfjord grounds, while two were included as parts of other cruises to Balsfjord and Kvaenangen. The cruises had in part as purpose to study biological parameters such as density and size distribution, and partly to test out technical aspect of the rake, rigging, deck arrangement and organization onboard. The technical aspects were evaluated during five cruises from Feb. 2 to August 14, 1978, and the results evaluated in consultation with skipper Kare Bendixen on "Ottar" and the technical staff that participated.

Results

The first cruise had as its main goal to evaluate some basic conditions with respect to how the further work should be planned. A simple triangular rake was used here (fig. 5), which is chiefly used for scientific sampling. This rake was judged to be not suitable for commercial fishing.

The trials with the Baird rake started with the second cruise. This rake is constructed as a sled with a level blade to scrape the bottom and a bag that originally would hang loose behind. It was found that the system with a loose bag was not practical and the loose bag was replaced with a wire mesh on a stiff steel frame (fig. 6). p. 16

This rake was tested during a cruise on February 28, 1979. It worked satisfactorily for our purposes. However, the catch in this rake also consisted of considerable quantities of empty shells, rocks and other debris that had to be sorted out. In order to make this work more easily, a sorting box measuring

2 x 1 m was built. This was constructed so that one side rested on the railing while the other rested on feet on the deck (fig. 9). The arrangement then became as shown on fig. 8. The rest of the sampling was carried out with this equipment.

During fishing the rake was shackled to the trawl wire and hauled through the regular trawl gallows. When the rake was hauled all the way up in the block, the runner hook was engaged and the rake taken in with the boom, while the trawl wire was let out. Directly over the sorting box, the rear gate in the rake was opened and the contents emptied out. When it was empty, the gate was closed and the rake lowered outside the railing as the towing wire was tightened. The runner hook was released and the rake was again ready to be set.

The sorting box had gates in both ends. At the end facing the deck, a box was placed to receive live scallops of suitable size. Debris, empty shells and undersize scallops were pushed out through the end resting on the railing.

The work onboard was carried out by three men. The skipper was mostly engaged in clearing, setting and maneuvering. While setting, heaving and emptying, the skipper had to be assisted by one man. During setting, one man was located on each side of the sorting box (fig. 8). The skipper assisted with the sorting when he had an opportunity.

Time used

During the cruises on March 10 and 14, measurements were made of how much time was needed for the various operations. Elapsed time was measured for a full rake under favorable working conditions but with inexperienced crews.

gunstige arbeidsforhold, men med lite rutinert mannskap.

Tabell 3. Table 3.

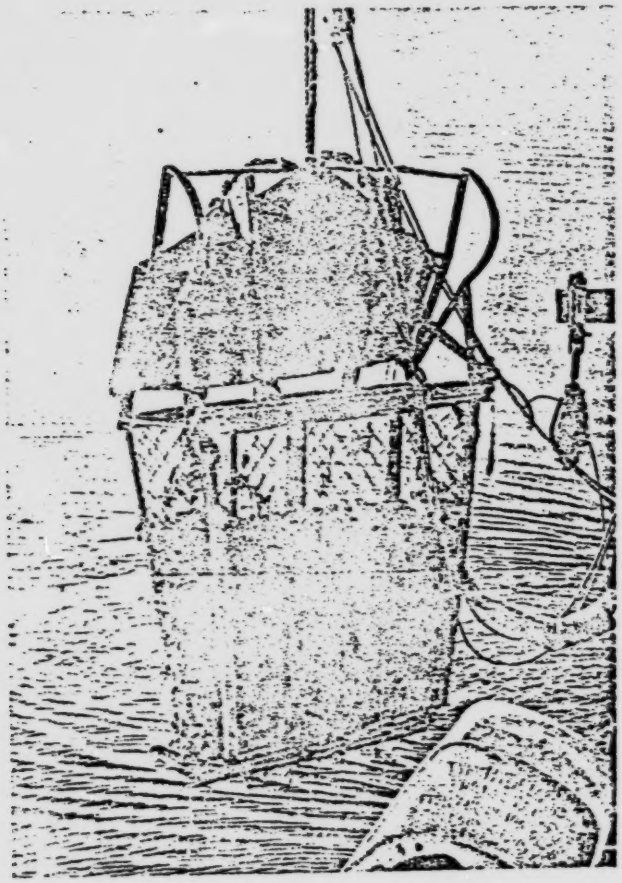
Tidsforbruk pr. skrapetrekk. Time used per rake haul.

Setting og skraping 81-2 mann) Setting and towing (1-2 men)	5 min.
Tømming og klargjøring (2 mann) Emptying and clearing (2 men)	5 "
Sortering (2-3 mann) Sorting (2-3 men)	15 "
Sum Total	25 min.

Figur 5.

Trekantskrape.

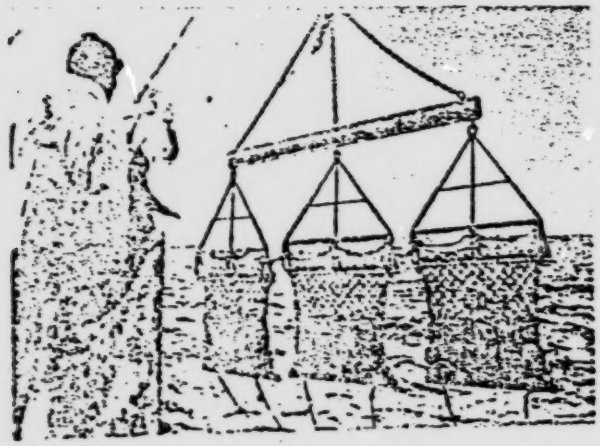
Triangle rake



Figur 6a. (6b: se n. side)

Ombygd Bairdskrape.

Rebuilt Baird rake.



Figur 7.

Kamskjellskrape fra Shetland.
Scallop rake from Shetland.
(Etter foto K. Hanssen)
(Photo by K. Hanssen)

Fig. 6b. Summary and details, see drawing A1-27. (page 28).

p. 18a

Böyle = hoop, ring
Aksel = shaft
Hylse = ferrule, socket, casing
Dekk-plate = cover plate
Kniv, fjaerstål = knife, spring steel
Tilpasse = adjust, fit in
Valse = roller

Scallop Rake
Part List

Page 18b (page 29)

mutterskruer = nuts
knekklinje = break line
samm lengde = true length

Page 18c (page 30)

10 " steel welded on for fastening mesh

Fig. 6b. Sammenstilling og detaljer se tegn. A1 - 27

Ant.	Gjenstand	Nr.	Materiale / Dim.	Merknad*
		35		
		34		
		33		
		32		
2	Bøyle ⌀ st. 40X1	31	520 lg.	
2	⌀ st. 20x6	30	40 lg.	
1	⌀ st. 20x10	29	275 lg.	
1	Bøyle, 12⌀	28	120 lg.	
1	Bøyle, akselst. 14,29⌀	27	Bl.vals 1480 lg.	tidl. 12,7 ⌀
2	Akselst. 14,29⌀	26	Bl.vals 265 lg.	tidl. 12,7⌀
3	Låsebøyle 25 x 6	25	50 lg.	
3	⌀-st. 25 x 6	24	200 lg.	
2	⌀ -st. 25 x 6	23	940 lg.	
3	Dobbelhylse ½ "gj.rør	22	21/15⌀ 40 lg.	tidl. 13 ⌀
1	Bøyle, akselst.14,29⌀	21	Bl.vals 1480 lg	tidl. 12,7⌀
2	Akselst. 14,29⌀	20	Bl.vals 455 lg	tidl. 12,7⌀
6	Rundst. 12⌀	19	Tils. 1850 lg.	
3	Akselst. 14,29⌀	18	Bl.vals 960 lg.	tidl. 12,7⌀
1	Akselst. 14,29⌀	17	Bl.vals 1250 lg.	tidl. 12,7⌀
23	Hylse ½ "gj.rør"	16	21 /15⌀ 40 lg.	tidl. 13 ⌀
2	⌀-st. 50 x 10	15	1020 lg.	
2	⌀ -st. 50 x 10	14	1000 lg	
2	⌀ -st. 20 x 10	13	1025 lg	
2	⌀ -st. 20 x 10	12	1005 lg	
1	Dekk-plate 2 mm	11	1250 x 780	
4	Bøyler	10	12⌀ stål	tilpasses
1	Kniv, fjærstål	9	75x16, 1250 lg.	
1	L 40 x 40 x 4	8	1220 lg.	tidl.25x25x3
1	L 50 x 50 x 5	7	1230 lg	
1	⌀ 40 x 6	6	700 lg	
2	L 40 x 40 x 4	5	720 lg	
2	L 40 x 40 x 4	4	780 lg	
2	⌀ -st. 40 x 6	3	440 lg	
2	⌀ -st. 40 x 6	2	780 lg	
2	⌀ -st. 40 x 8	1	950 lg	tidl. 40 x 6

SKJELLSKRAPE.

STYKKLISTE.

Målestokk

Tegn. 15.2.79

Trac. Stein Svendt

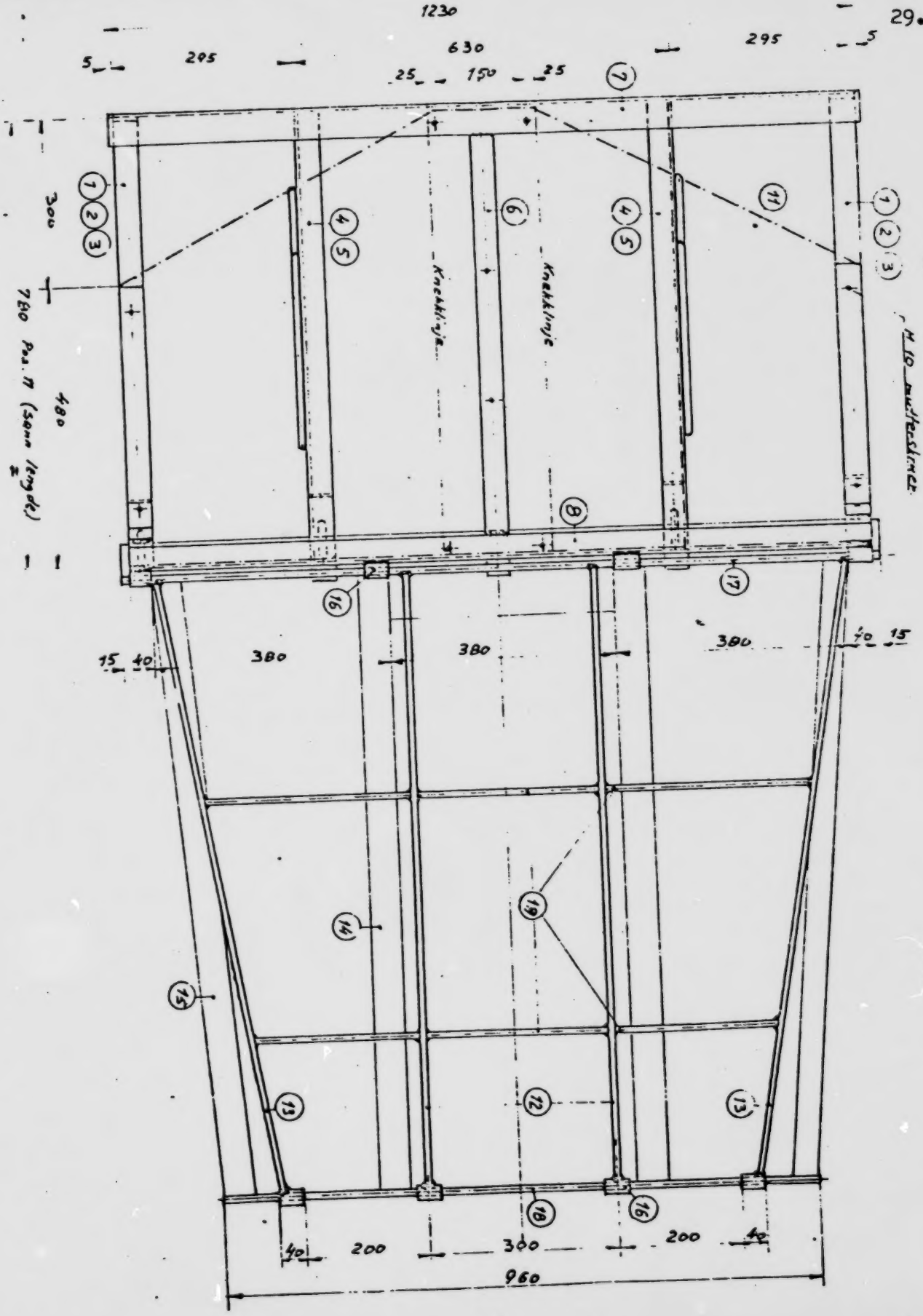
Kfr.

Erstatning for:

UNIVERSITETET I TROMSØ

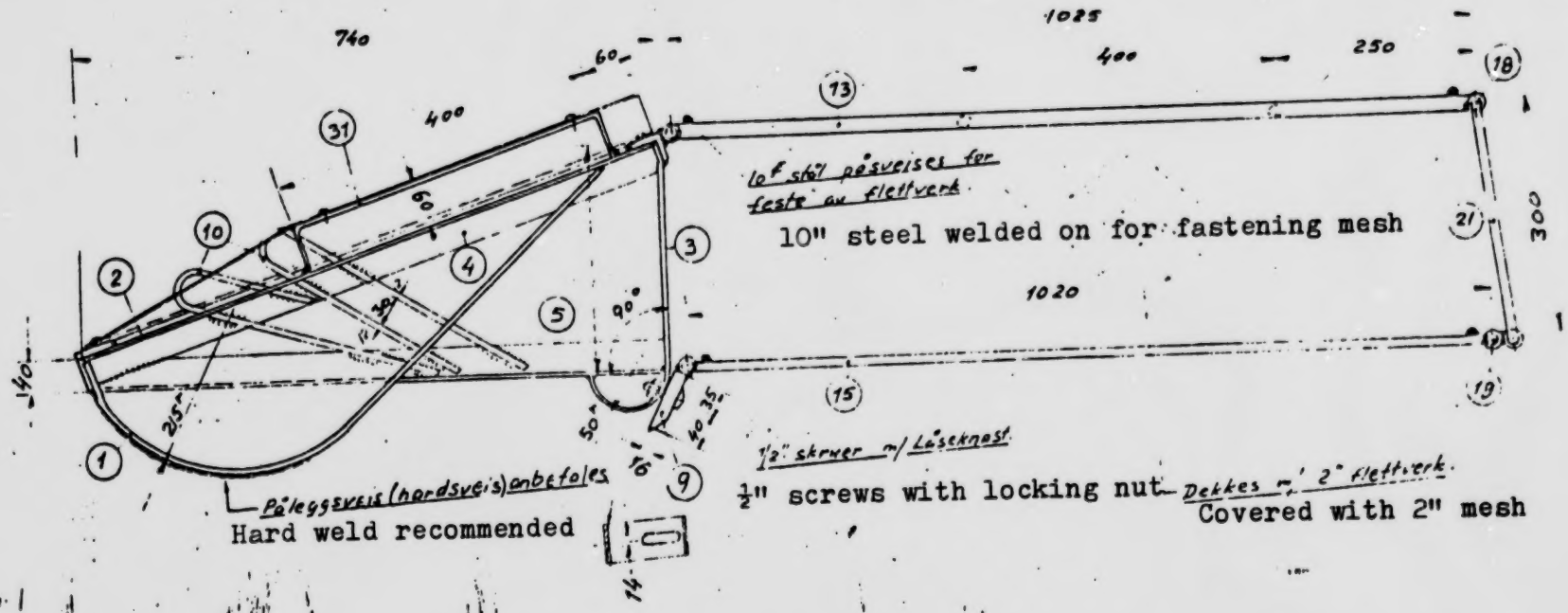
INSTITUTT FOR FISKERIFAG

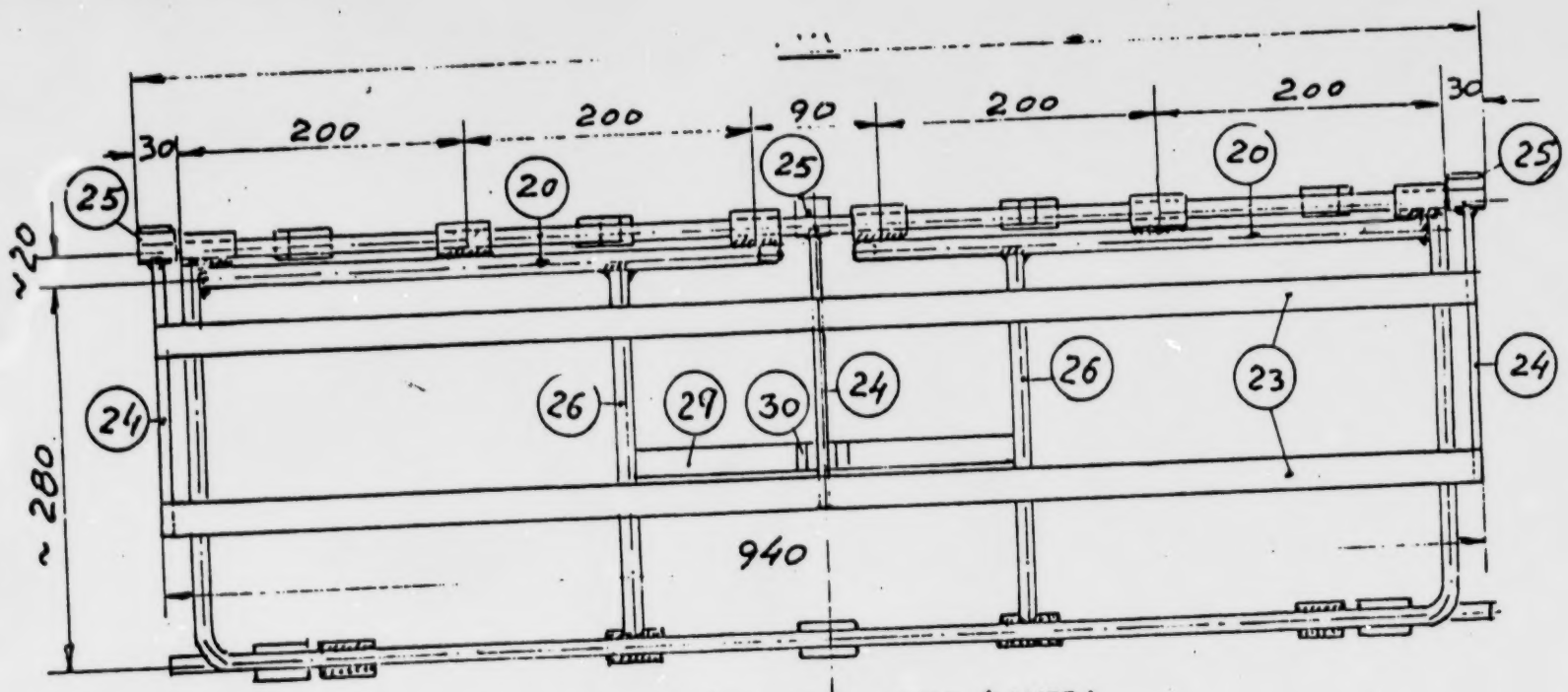
A4 - -28.


1230
630
295
205
5
25
150
25
300
480
780
Pos. 11 (Som ring del)
Knekklinje
Knekklinje
380
380
380
15
40
40
15
200
300
200
40
40
960

p.18b

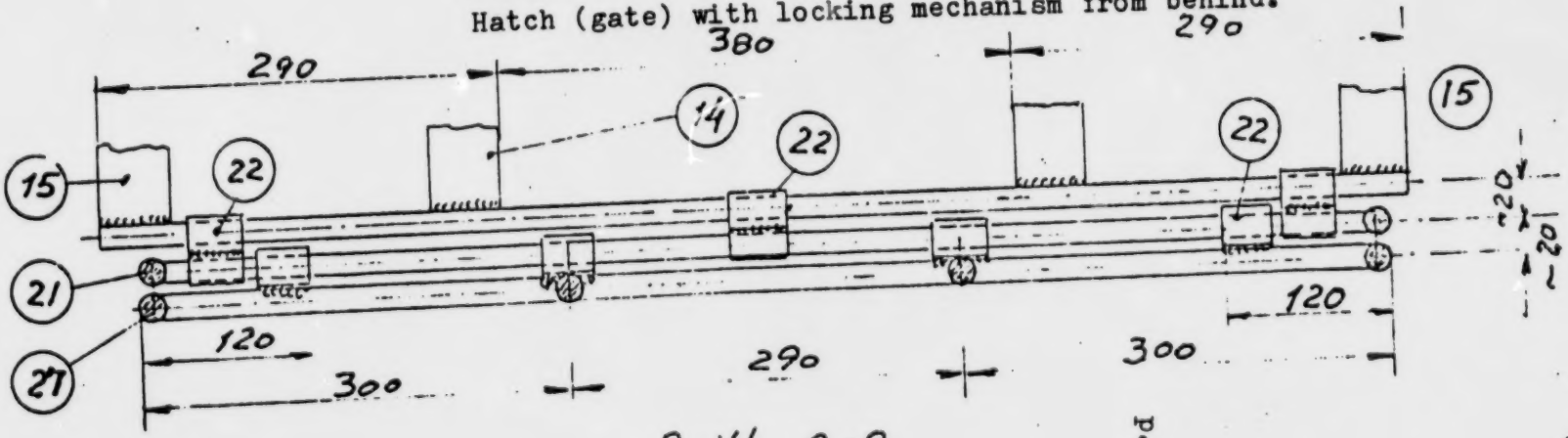
30.


740
60
1025
400
250
400
60
1020
300
140
215°
90°
50°
40
35°
16
14
10" steel welded on for fastening mesh
½" screws with locking nut
Hard weld recommended
Covered with 2" mesh



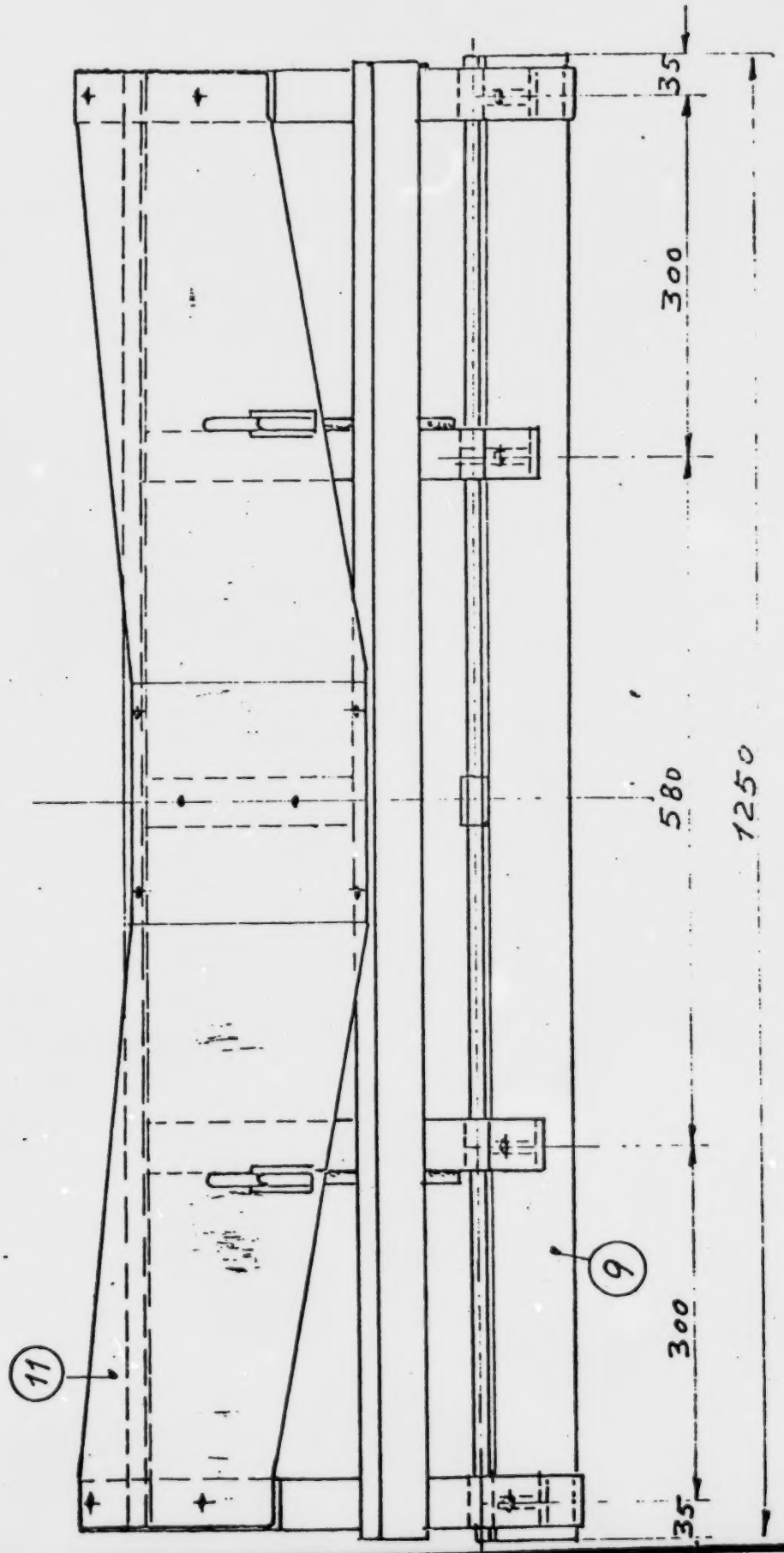
LUKE M/ LÅSANORDN. SETT BAKFRA.

Hatch (gate) with locking mechanism from behind.



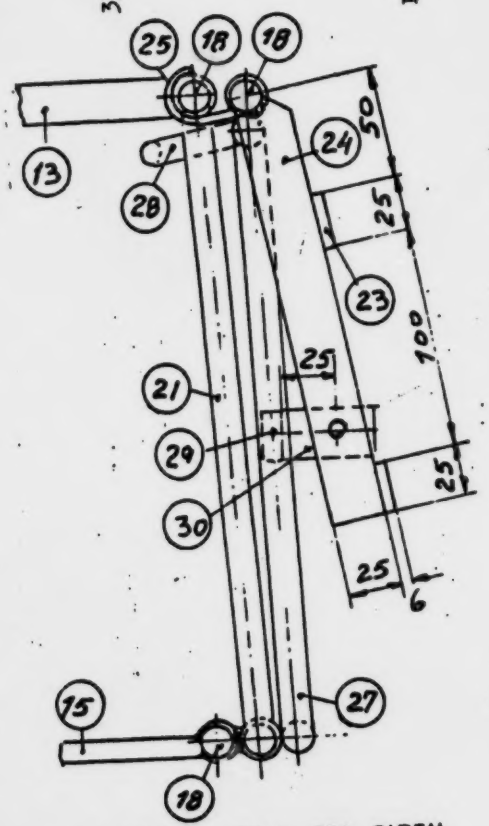
Snitt a-a.

p. 18e



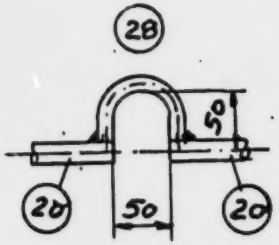
33.

p. 18f



LUKE M/ LÅS SETT FRA SIDEN.

M. 1:5



DETALJ.

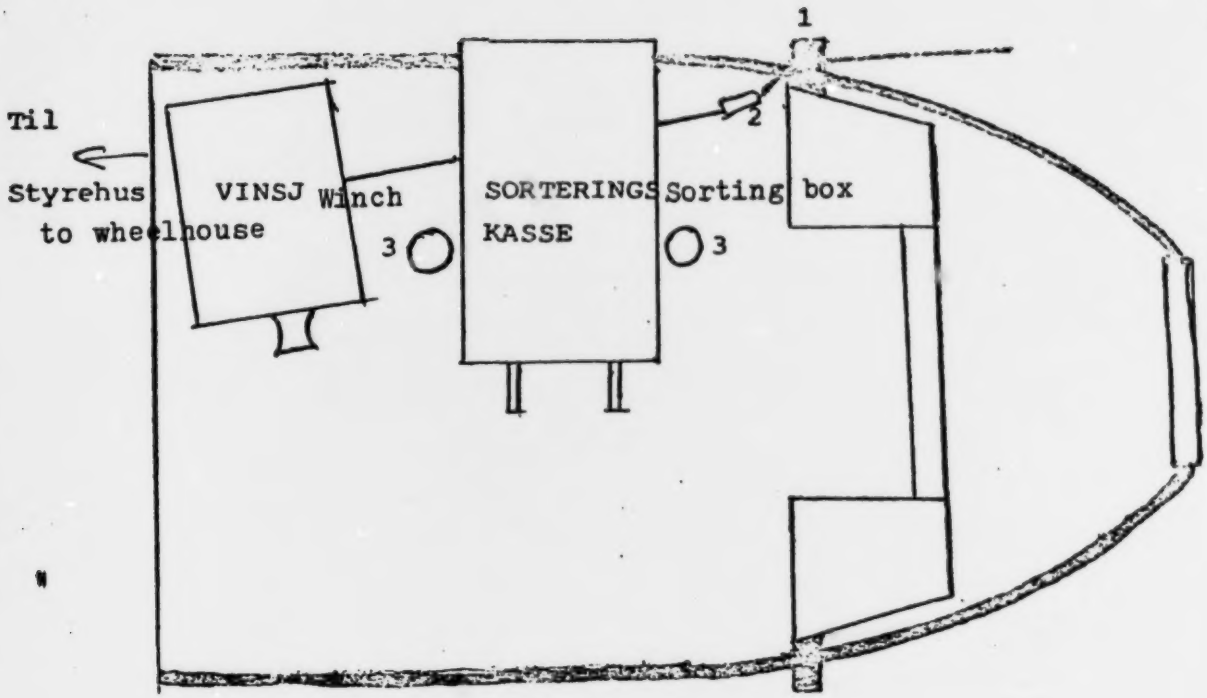
NB! Sett bössinger på ϕ-stål för bukking og sveising.

NB! Place bushings on O steel before welding.

Stykkliste se A4-28.

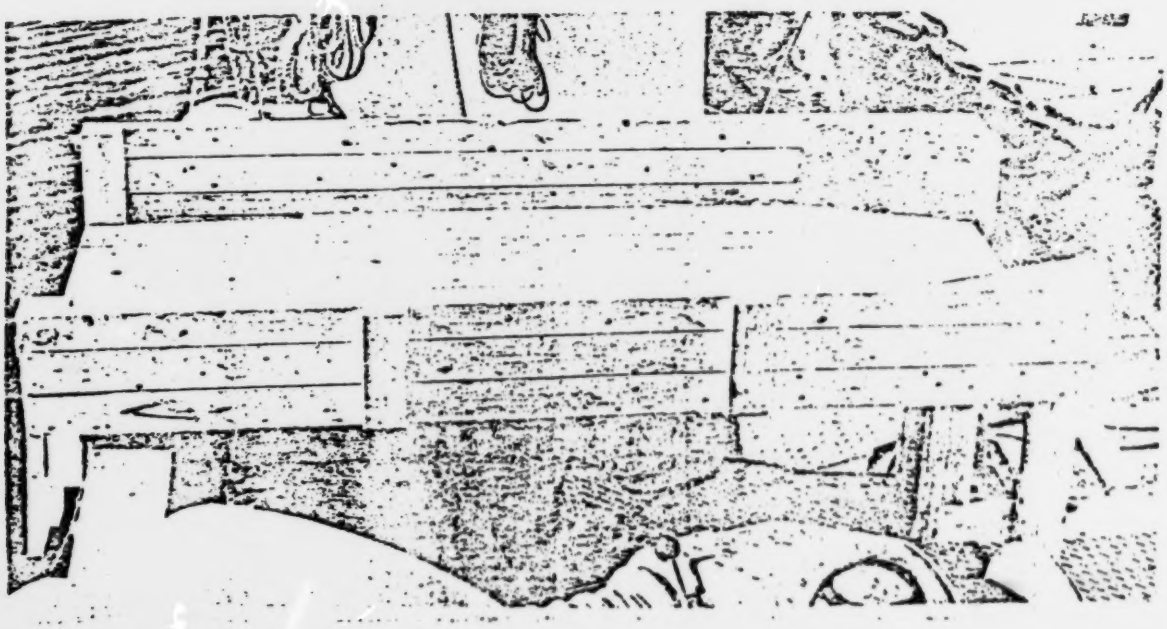
Gate with lock seen from the side.
Parts list see A4-28

Ant.	Gjenstand	Nr.	Materiale / Dim.	Merknad
	SKJELLSKRAPE. SCALLOP RAKE		Målestokk 1:2.5 1:5	Tegn. V4.2.79 Trac. G. Sivertsen Kfr.
	UNIVERSITETET I TROMSØ INSTITUTT FOR FISKERIFAG			Erstatning for: A1- -27.



Figur 8. Figure 8. Deck arrangement R/V "Ottar"

Dekksarrangement F/F "Ottar". 1)Trålgalge. 2) Fotblokk.
3) Mannskap. Crew 1)Trawl gallow 2)Leading block



Figur 9. Figure 9. Sorting box on R/V "Ottar"

Sorteringskasse F/F "Ottar".

It can be seen that the most time-consuming and labor-intensive part of the operation was the sorting. By making a new set immediately after the rake was emptied, continuity was maintained in sorting and time saved. Two men were required for setting, raking, towing and hauling back, but these work operations could have been carried out by the skipper alone if "Ottar" had been equipped with remote steering or auto-pilot. p. 20

Density

On the grounds at Berg in Balsfjord, the density has been sampled at depths of 25 to 30 metres by diving. A square frame measuring 0.25 m^2 was used; it was placed on the bottom, and all scallops inside the frame were taken to the surface for counting and size measurements. A total of 20 such samples were taken; a total area of 5 m^2. The size distribution in the population is given in fig. 10. The total number of scallops was 375 which averages out to 75 scallops per m^2. The number of scallops above 65 mm in the diving samples was 167, i.e. 33 per m^2.

Catch rates

The trial fishing on the Balsfjord grounds (fig. 11) gave varying results (table 4). The catch rates were best from Bergholmen north. From Bergholmen southwards to Eriksfjord, on Halvaren and at Berggrunnen the catch rates were lower. The catch rates at Berg (area b, fig. 11 and table 4) are from several cruises and the raking was carried out under good weather conditions. The experimental fishings on grounds 1-5

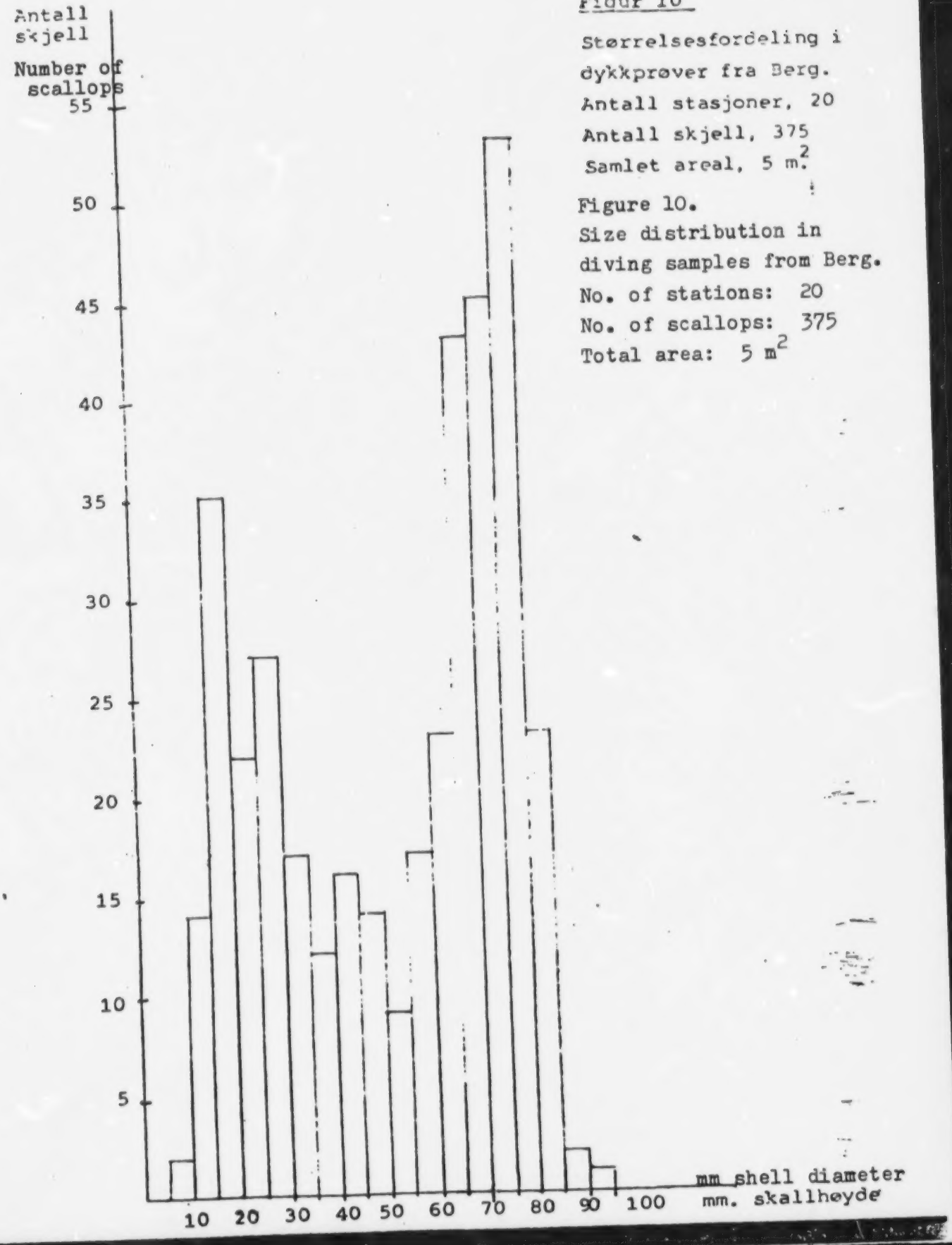
and 7 (fig. 11) were, however, carried out under poor weather conditions. The catch rates from these samples are therefore more unreliable than those found for Area 6.

On the Berg grounds the rake was mostly full on each haul. This corresponds to from 80 to 100 kg scallops larger than 65 mm. One can therefore count on a capacity of about 200 kg per hour for the arrangement, crew and equipment used. Daily catches of 1500 kg should therefore be possible.

Figur 10

Størrelsesfordeling i dykkprøver fra Berg.
Antall stasjoner, 20
Antall skjell, 375
Samlet areal, 5 m^2.

Figure 10.
Size distribution in diving samples from Berg.
No. of stations: 20
No. of scallops: 375
Total area: 5 m^2



Tabell 4.

Fangstrater og skrapeforhold for haneskjellfeltet i Balsfjord.

Catch rates and fishing conditions for the scallop grounds in Balsfjord.
(Skrapetid: 1 - 1½ minutt.)

Dragging period: 1 - 1½ minutes.

Område / Area	* Fangstrater av skjell over 65 mm. (kg/min. skraping) / *Catch rates of scallops over 65 mm kg/min raking	Antall trekk / Number of hands	Anmerkninger / Notes
1. Langs Balsnes og sør for Berggrunnen / 1. Along Balsnes and south of Bergrunnen	Svært lite skjell. Very few scallops	4	
2. Berggrunnen/ østkant / 2. Berggrunnen/ eastern edge	10 - 15 kg.	3	Mye små skjell. Mye rask. / Many small scallops and much debris
3. Halvaren / 3. Halvaren	15 - 20 kg.	2	" " Mye små skjell. Mye rask.
4. Erikjord/ Holmsletthl / 4. Erikjord/ Holmsletthl.	20 kg.	1	Brukbar skjell. Mye rask. / Usable scallops, much debris
5. Holmsletthl/ Berghl / 5. Holmsletthl/ Berghl.	40 kg.	1	Gode skrapeforhold. / Good fishing conditions
6. Bergholmen/ Kuberg / 6. Bergholmen/ Kuberg	80 - 100 kg.	4	Gode skrapeforhold. Mest stor skjell. / Good consitions, mostly large scallops
7. Kuberg/ Kaldsletta / 7. Kuberg/Kaldsletta	30 - 50 kg.	3	Stor skjell. Mye tomskall. / large scallops, many empty shells.

Selektivitet. Selectivity

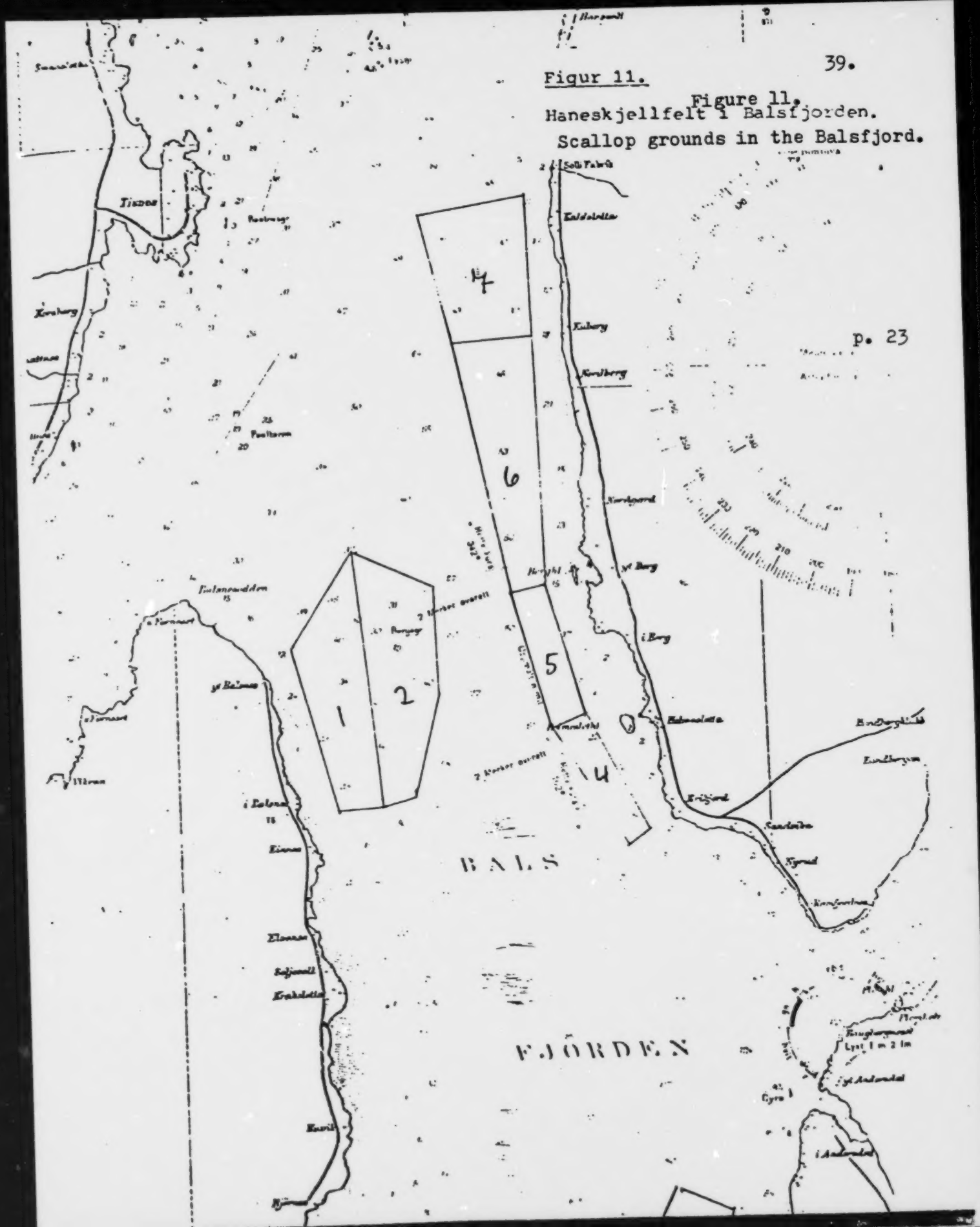
Størrelsesfordelingen i dykkprøver og skrapetrekk (fig. 12) viser at skrapen fanger selektiv på store skjell. I skrapetrekkene var 12% av skjellene under 65 mm., mens 45% av skjellene i dykkprøvene var under denne størrelsen (fig. 13).

The size distribution in diving samples and hauls with the rake shows that the rake selectively catches large scallops. In the hauls with the rake, 12 % of the shells were below 65 mm shell diameter, while 45% of the scallops in the diving samples were below this size (fig. 13).

Figur 11.

Figure 11.
Haneskjellfelt i Balsfjorden.
Scallop grounds in the Balsfjord.

p. 23



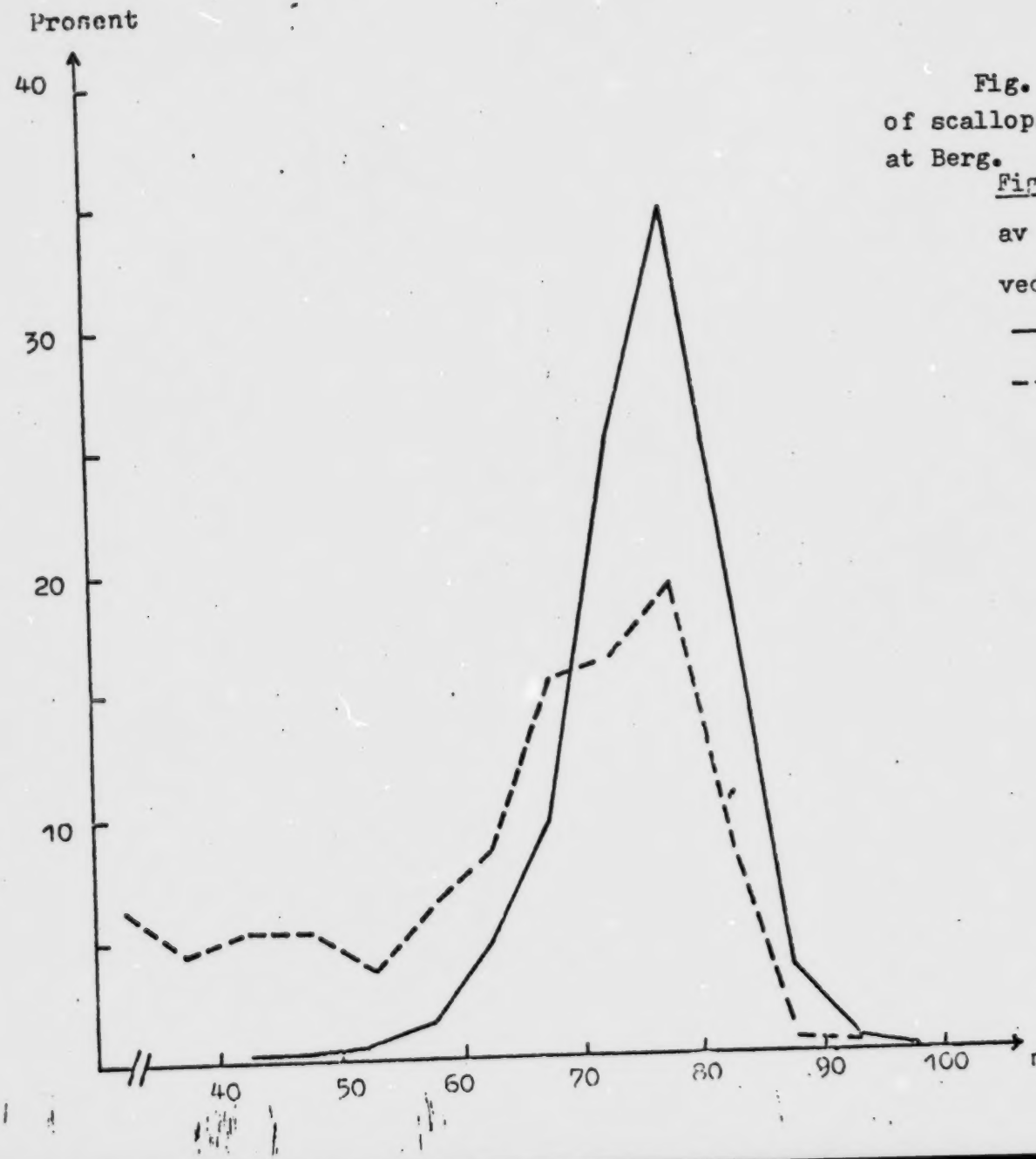


Fig. 12. Distribution in percent of scallops over 30 mm. The grounds at Berg.

Figur 12. Fordeling i prosent av skjell over 30 mm. Feltet ved Berg.

—— Hauls with rake Skrapetrekk

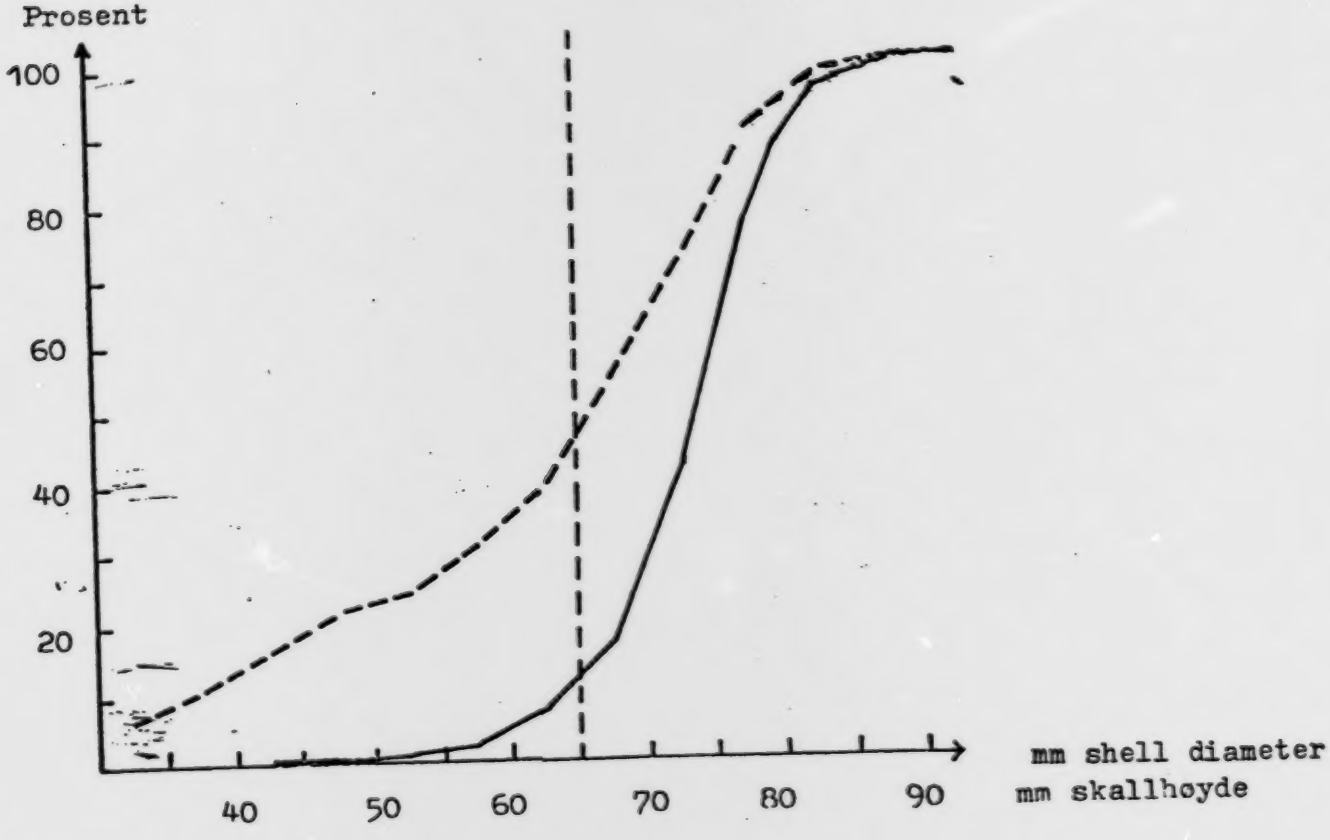
--- Diving samples DykkprøverDiving samples

Fig. 13. Cumulative frequency of scallops over 30 mm from the grounds at Berg.

Figur 13. Kumulativ frekvens av skjell over 30 mm fra feltet ved Berg.

Skrapetrekk ———— Rake samples

Dykkprøver — — — Diving samples



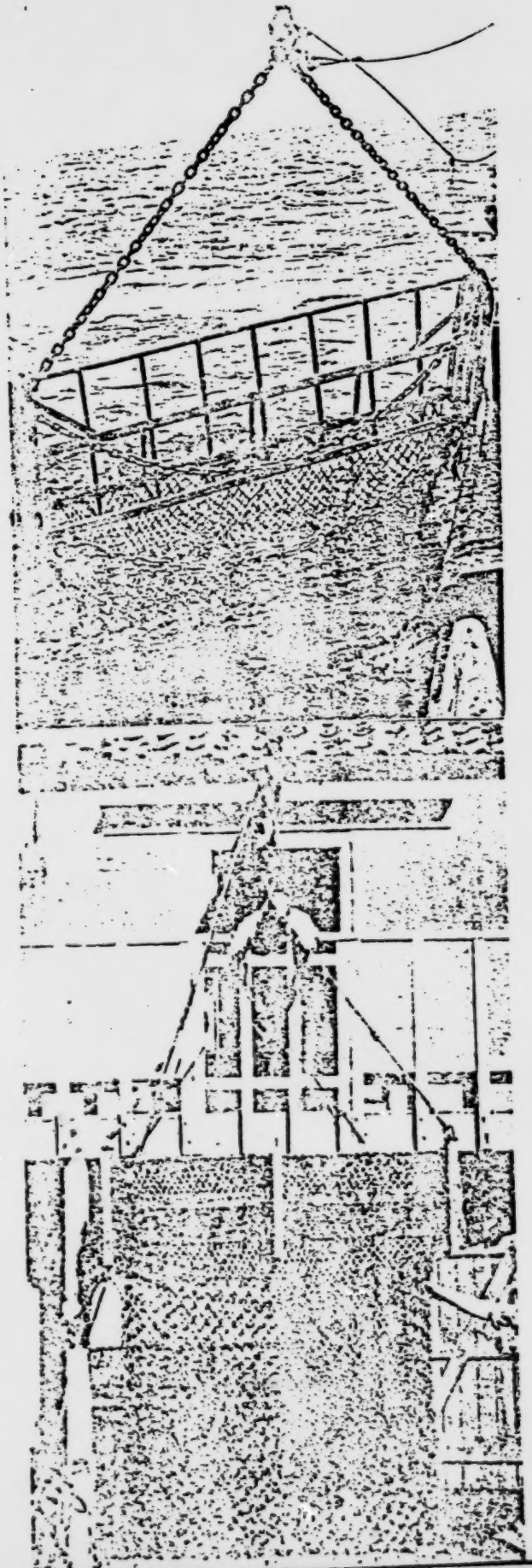
Iceland Scallop fishing in Iceland.

During a visit to Stykkisholmur we had an opportunity to study the technical equipment and the organization of the fishery for Iceland Scallop in Iceland. The observations were made in the harbor in Stykkisholmur and on the grounds onboard the M/V "Grettir".

The fishery in Iceland is concentrated on the grounds in Breidafjord. The concentrations are spread across shallow areas in the whole fjord with a maximum steaming time from Stykkisholmur of ca. 2 hours. Only vessels from the district around Stykkisholmur have the opportunity to fish scallops and the plants have established daily quotas for each vessel. There are now eight vessels that have permission to fish for scallops (Solmundur Einarsson; pers. comm.).

All vessels fishing for scallops are traditional vessels that were earlier rigged for trawl and gillnets. Some of them still combine scallop fishing with gillnet fishing in the winter, while some vessels now are scalloping the whole year (August Sigurdsson, pers. comm). The vessels depart at six or seven in the morning and return as soon as the daily quotas are taken. This usually occurs at four or five in the afternoon. Due to processing schedules (page 33), the vessels fish only from Sunday to Thursday and are tied up Fridays and Saturdays.

All vessels were rigged in a similar way. The type of rake used was nine feet wide and was called the "Scottish Plow" (fig. 14). This rake resembled the "Blake rake" (fig. 15). Both rake types are constructed on a frame of strong iron with a bag hanging loose behind. They are both different from the



Figur 14.

Islandsk hanеskjellskrape hengende i trålgalgen.

Figure 14. Iceland scallop rake hanging in trawl gallow.

Figur 15.

Blakeskrapa sett fra undersiden.

Figure 15.
The Blake rake seen from below.

"Baird rake" (fig. 6) in that they do not have a fixed blade, but a system of chain links that glide along the bottom. The lower part of the bag is fastened to the back part of these chains while the upper part is fastened to the frame itself. The lower part of the bag consists of solid link chain, while the upper part is made of strong nylon twine of the same type as is used in trawl codends.

The rake was shackled to an ordinary trawl wire on a drum. The wire went through the usual system of guiding blocks and foot blocks and out through the trawl gallow on starboard side. The deck arrangement for handling the catch consisted of a platform that rested on the starboard railing and extended over the hatch to about 1.5 metres from the port railing (fig. 16). From here there was a chute from the platform out through a part in the rail (fig. 17). The platform was about 2 x 3 metres and took up most of the space between the winch and engine casing. p. 28

"Grettir" is a steel vessel of about 70 feet with a high-speed Cummings diesel engine of 425 HP. The vessel had echo sounder and radar, but not Loran C which is the navigational system used in Iceland.

The crew consisted of seven men: Skipper, bosum, cook and four fishermen. The skipper was only occupied with maneuvering and navigation. The bosum operated the winch, organized the work on deck and looked after the engine, but he participated in other activities when he had time. The cook also participated in the work on deck.

After the vessel had reached the grounds, the rake was

lifted over the rail with the runner wire and the towing wire tightened. A hook in the runner wire (a release mechanism) was used that could be released with a rope from the wheel house. The setting of the gear was carried out at full speed and with drum and brake released. A relatively long wire was used, probably at least five times the depth. Only a small part of the engine power was used during dragging and the speed was estimated to be two knots. The length of a haul varied from ten to eighteen minutes.

After the rake was hauled back all the way up in the gallow, the runner hook was engaged and the whole rake lifted onboard as the warps were slackened. The rake was placed on the platform, the hook disengaged and fastened in the back of the bag so that the whole rake could be turned around and emptied. The crew started right away to sort the catch while skipper and bosum made clear for a new haul. The bosum heaved the rake over the railing and tightened the warp. The next set started as soon as the vessel was in the correct position. While sorting, the crew positioned themselves around the platform with an iron rake each and a basket of the type used to cook shrimp (fig. 17). They raked a suitable amount towards themselves and all scallops large enough were picked out and thrown in the basket. When the basket was full, it was emptied into aluminium containers that each could hold ca. 500 kg of scallops. Empty shells, small scallops and debris were pushed out over the railing on starboard side or into the chute on the port side. p. 30

The catch varied from almost nothing to 3-400 kg scallops

per haul. The reason for the large variations is not known, but since empty hauls only occurred when the vessel was towing with the current, the variations can have a connection with current conditions. Registrations on the echo sounder showed that the bottom was hard and quite uneven, but the rake travelled smoothly and largely without problems. The depth varied from 10 to 25 fathoms.

The daily quota of about seven tonnes was filled in 14 containers that all were placed around the deck. These were unloaded with the vessel boom on to a truck. This had to make two trips up to the plant, and the unloading took ca. 45 minutes.

Other Scallop fisheries.

Since the Queen Scallop has many similiarities with the Iceland scallop, both with respect to biology and possible product types, the British fishery for Queens is interesting to study. Queens were first taken as bycatches in the fishery for large scallops, but gradually a separate fishery for Queens has developed (Mason 1972, Rolfe 1973).

Originally light triangular rakes with teeth were used (fig. 18). These rakes caught, however, large quantities of small rocks and debris, and the "Blake Rake" (fig. 15) was developed. This type of rake takes longer to fill, but the catch is much cleaner (Rolfe 1973).

In the fishery for Queens, each vessel usually operates with two rakes, one on each side of the vessel. The hauls usually take about one hour, and the net length is three times the depth. The speed during the haul is as

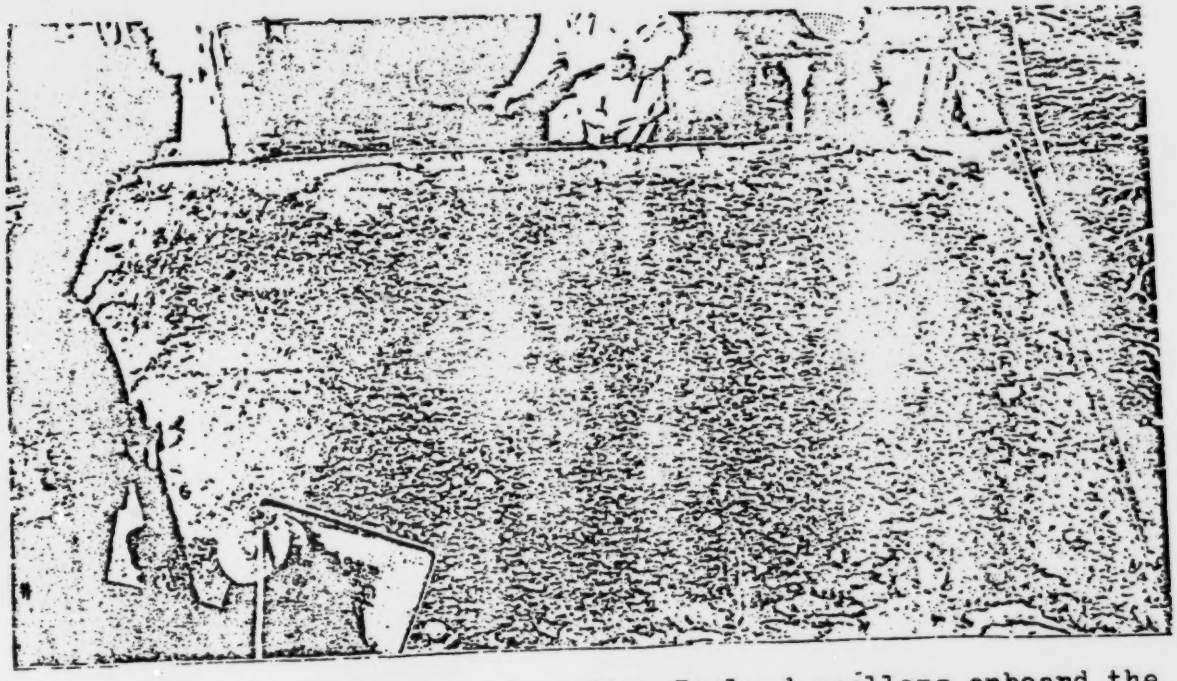
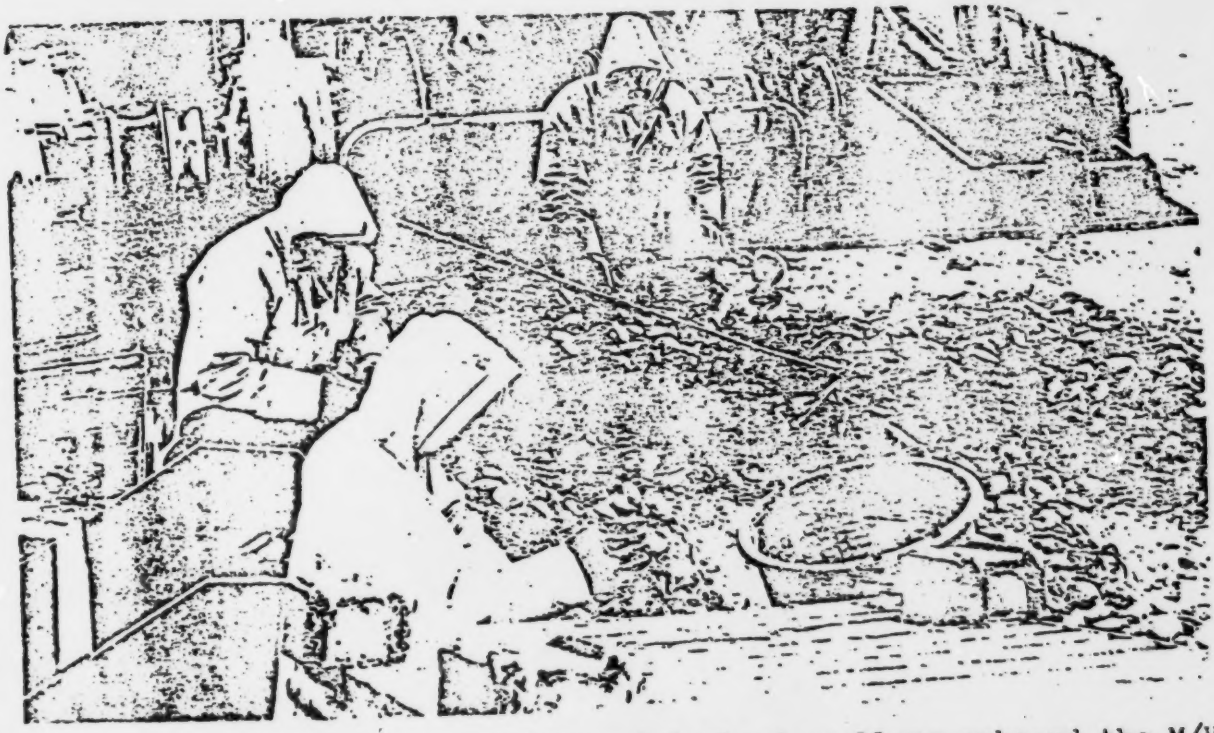


Figure 16. Platform for sorting Iceland scallops onboard the M/V "Grettir".

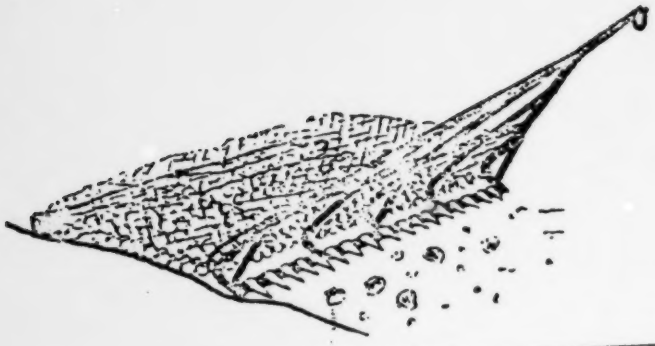
Figur 16.

Platt for sortering av haneskjell ombord på M/Kr. "Grettir"



Figur 17. Figure 17. Sorting of Iceland scallops onboard the M/V "Grettir". Note the basket and the chute leading to a port on the port side.

Sortering av haneskjell ombord på M/Kr. "Grettir" Merk kurven og renna som går til svalk i babord rekke.

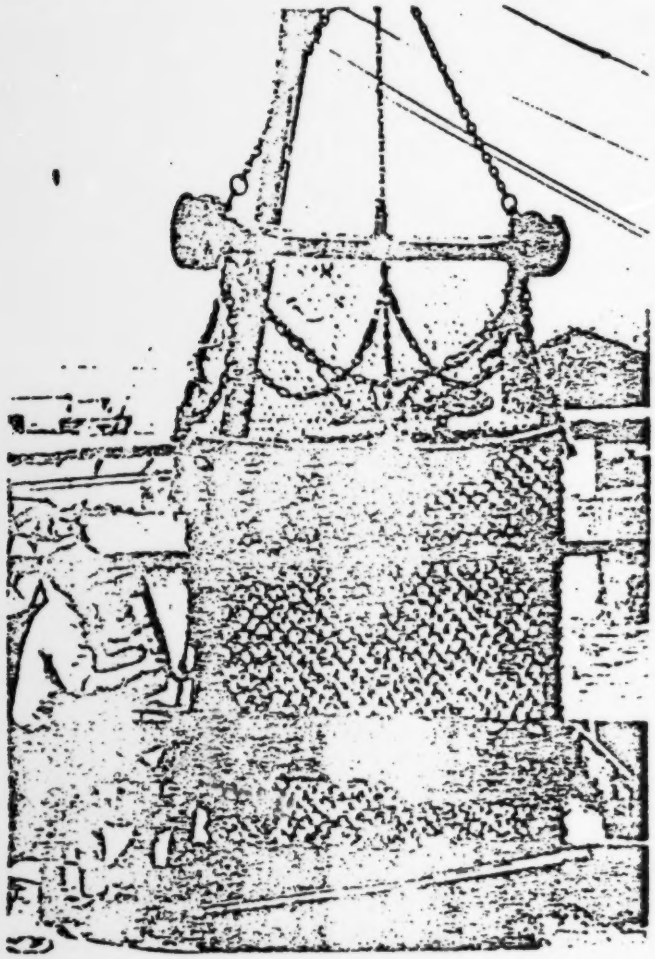


Figur 18.

Standard britisk kam-skjellskrape med tenner.

Figure 18.

Standard British Queen scallop rake with teeth.



Figur 19.

Conolly Roller-dredge.

Figure 19.

Conolly Roller Dredge.

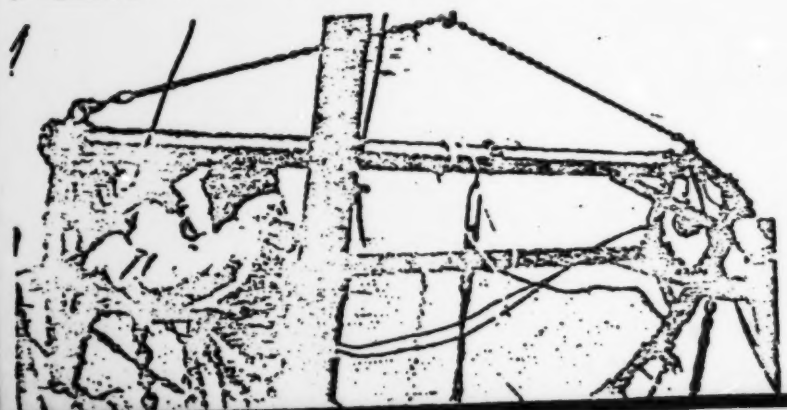


Figure 20. Beam trawl designed for Queen scallops.

Figur 20.

Bomtrål beregnet på harpe-skjell.

high as possible without the rake lifting from the bottom (Rolfe 1973).

In addition to the "Blake Rake", other types of gear are also used in this fishery. A rake called the "Connolly Roller-dredge" (fig. 19) is assumed to be more effective on hard bottom than the "Blake Rake" but not as suitable on soft bottom. In addition to these two rakes, trials have been made with gear based on other principles, for example otter and beam trawls (fig. 20). The last mentioned have especially proven themselves to be effective (Rolfe 1973). p. 32

Catching efficiency of various rakes.

The rakes used on the Queen Scallop grounds at Guernsney (probably "Blake Rakes") have an efficiency of 17%. This means that they catch 17% of the scallops on the bottom (Broom 1976). Beam trawls used on the Devon grounds can have an efficiency of up to 40-50%. However, the efficiency of the various gears is very dependent on the bottom type (Broom 1976).

At Berg in Balsfjord there are on an average 33 scallops over 65 mm per m^2 (suggested minimum size, see page 13). In three hauls in the same area, a total of 2584 scallops over 65 mm were caught. Each haul covered about 50 m^2. This gives a catch rate of 17 scallops per m^2. The catch efficiency of our modified "Baird rake" is therefore ca. 50 %.

Scallop species can be very mobile. Underwater observations in Scotland have shown that Queen scallops swim up in large numbers and escape in front of a beam trawl (Rolfe 1973). Similar studies have not been carried out on Iceland scallops,

but they can also swim and there are several reports of great mobility in the literature (Brun 1968, Pettersen 1976, Vahl and Claussen 1979). This is an important side of the biology of the Iceland scallop and must be considered in connection with the construction of gear.

The trials on the Berg grounds (page 15ff) indicated that sorting is a bottleneck in the fishery (table 3). It is therefore important that the rakes do not take too much debris together with the scallops. A rake that catches "only" scallops can therefore be more suitable than one that has high efficiency but which catches too much debris.

III. Processing and Marketing of Iceland Scallops

p. 33

Unprocessed products

Sale of round scallops will not require any processing apparatus and can take place directly from fisherman or via a middleman. Such sales will be limited to the district where the fishery is carried out and possibly the major towns in Southern Norway. The freight costs to Oslo/Bergen/Trondheim will, however, be so high that large scale marketing of round scallops will hardly be practical.

Processed products

There are several possible product types from Iceland scallops. The Sigurd Augustsson company in Stykkisholmur, one of the two companies on Iceland producing Iceland scallops, today has three product types (August Sigurdsson, personal communication):

1. The total soft tissue
2. Muscle and gonad (rims and gills removed)
3. Pure muscle

It is possible that other products can also be produced. However, since it will probably be easiest to market established products the discussion will be limited to the above mentioned products.

Processing technologies

During the visit to the Sigurd Augustsson Co. plant, we had an opportunity to see all the processing equipment with the condition that the information should not be used in this publication. However, there is so much known from public documents that a description of possible processing techniques can be given.

The processing of Iceland Scallops can be divided into three main operations:

1. A shucking operation. This means a process to get the shells to open and to loosen the muscle from the shell. p. 35
2. A sorting function to separate the soft tissue from shell and shell fragments.
3. If the product is not to consist of all the soft tissue, a method to remove the unwanted parts.

All these operations can be carried out manually, but it is also possible to utilize technical equipment at one or several stages. A flow diagram of the processing is given in fig. 21.

Shucking

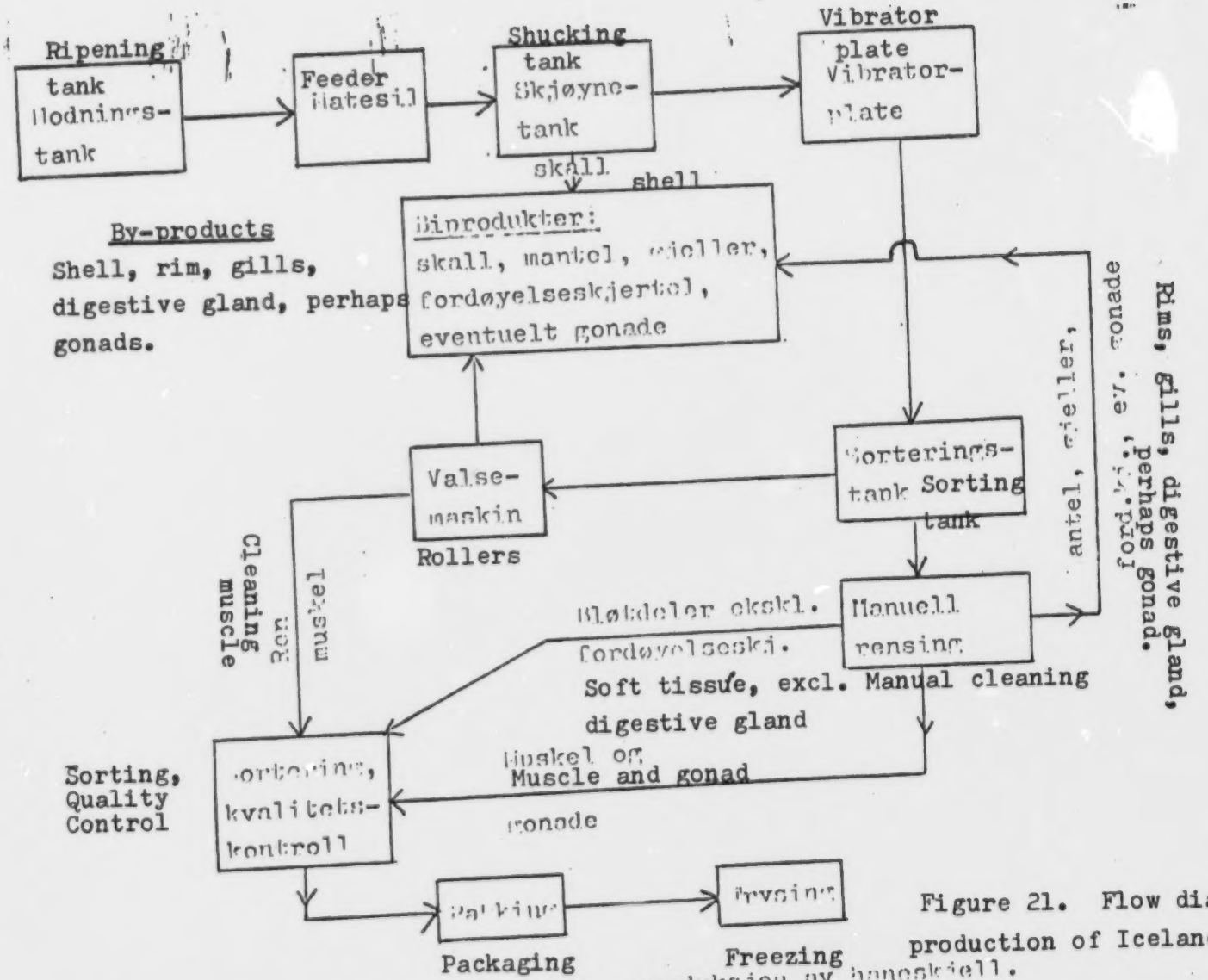
Manual shucking can be carried out with a curve knife or similar instrument. The knife is forced in between the shells where an opening is found (near the shell hinge) and the muscle is scraped loose from the shell. This method was formerly used by the Norwegian plants that processed Iceland scallops, (H. Richardsen, personal communication) and in the first years Iceland scallops were processed on Iceland (August Sigurdsson, personal communication). Some of the large scallop species are still being shucked this way (August Sigurdsson, personal communication).

With mechanical shucking, the problem is to get the muscle to loosen from the shell without cooking. By cooking, it will always loosen, but since the product should be raw when sold, other methods should be tried.

Nelson (1970) describes a method based on exposing the shell to a direct flame. This method also included a cleaning procedure based on removing the rims and gills with a water suction pump. Methods have also been tried based on exposing the shells to microwave radiation (Olafsson 1972). None of these methods are in use today, as far as we know (August Sigurdsson, personal communication).

The shucking method that has been proven to be most effective is described in U.S. patent No. 3,562,855 of Feb. 16, 1971. Equipment for a whole processing line is there patented by the company Willis Brow. Inc., Willingston, North Carolina.

The principle for this shucking method consists of lowering the scallops into warm water for a short period (6-10



Figur 21. Framstillingsskjema for produksjon av hjerneskjell.

Figure 21. Flow diagram for production of Iceland scallops.

seconds) followed by shaking on a vibrator plate. (fig. 22). This plate is perforated so that the soft parts fall through while the empty shells remain. The shaking should be a vigorous as possible without breaking the shells. The efficiency is improved if the shells are chilled immediately after heating (our own experiments). Since the product should be raw when sold, the chilling will also improve the quality of the product.

This equipment was originally intended for the processing of Calico scallops and was installed onboard three factory vessels (Cummins and Rivers 1970). The method has had mixed success (August Sigurdsson, personal communication). However, it has been further developed and is today used with good results on Iceland scallops in Stykkisholmur on Iceland and on Queen scallops in Scotland (I. Pettersen, pers. comm.). At the Sigurd Augustsson Co. plant, it was estimated that at least 95% of the scallops were successfully shucked this way.

Experiments at H. Richardsen Ltd in Tromso have, however, shown that the efficiency is dependent on the shells being in a certain condition when they enter the process. Scallops that are shucked completely fresh or ~~that~~ have been left in air overnight, are very difficult to shuck by this method. In shells that have been left overnight in fresh water, the muscle will, however, separate quite easily from the shell. This is probably associated with the shells dying and going into rigor when left in fresh water. The muscle will therefore be in tension and more easily let go the shell when shock-heated.

Sorting

There will always be a considerable amount of small pieces of shell, etc., that follow the soft tissue through the perforated vibrator plate. This can be removed in a floatation tank with a salt solution where the salt concentration is adjusted so that the soft tissues will float while the shell fragments sink (U.S. patent no. 3,562,855). If, in addition, the water is rotated with a water jet, the soft parts can be removed simply with a conveyor belt from the surface of the tank. Debris can be removed from the bottom with a conveyor belt (fig. 23).

Cleaning

Products consisting of pure muscle and muscle with gonad must be cleaned to remove unwanted soft tissue. There is today no knowledge of technical equipment for such cleaning. Muscle and gonad can therefore today only be produced manually. p. 38

If the product is pure muscle, the cleaning can be carried out mechanically; the equipment for this is described in U.S. Patent No. 3,562,855. The cleaning principle is based on the muscle passing over a number of oscillating rollers (fig. 24). These are constructed so that they grab on to the unwanted soft parts and pull them down while the muscle is held back (fig. 25). The principle is well known from shrimp peeling machines, but the construction is somewhat different in that the machine for cleaning scallops has the rollers across the path, while the shrimp peeling machines have the rollers lengthwise.

Figur 22.

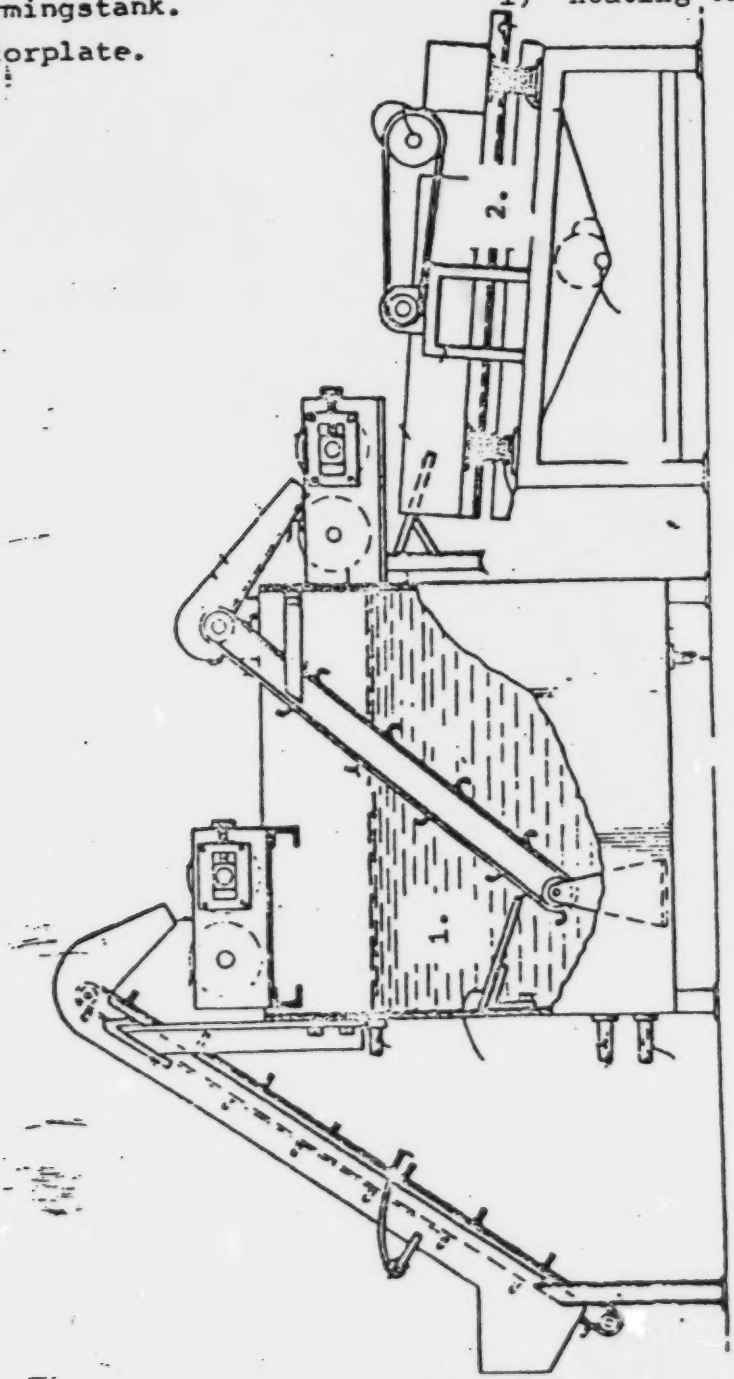
Utstyr for skjøyning av kamskjell.
(Etter US. pat. No. 3.562.855.)

1) Oppvarmingstank.
2) Vibratorplate.

Figure 22.

Equipment for shucking scallops.
(after U.S. Patent No. 3,562,855)

1) Heating tank
2) Vibrator plate



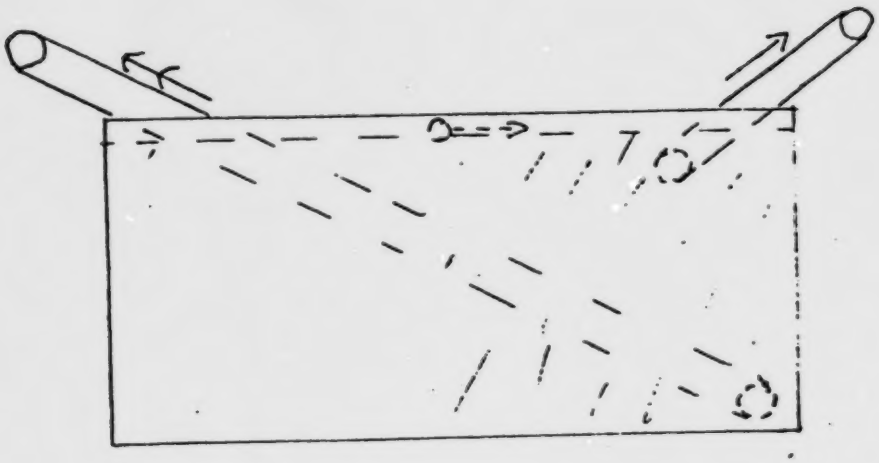
An experiment to clean Iceland scallops on ordinary shrimp peeling machines in the H. Richardsen Ltd. plant was not successful. It appears that Iceland scallops need a harder cleaning than shrimps. The surface of the rollers should be rougher and the scallop muscles must be in the machine longer than shrimp in order to be cleaned.

Both the shucking, sorting and cleaning procedures are fully mechanized at the Sigurd Augustsson plant. The system seems to work very well. Both shucking and cleaning was earlier carried out manually at this plant, but this required a labor force at least ten times as large (August Sigurdsson, pers. comm.). At another plant in Stykkisholmur there was automatic shucking but manual cleaning. This plant had about the same workforce as Sigurd Augustsson Co. but could only handle about 12-13 tonnes raw material per day while Sigurd Augustsson took about 40 tonnes per day (August Sigurdsson, pers. comm.). At the experimental production at H. Richardsen Ltd. in Tromso, only about 2 kg muscle per employee per hour could be cleaned by using manual cleaning.

Packing and preservation

Cleaned scallops can probably retain satisfactory quality in fresh condition for several days if properly handled. Such a product will probably have a certain domestic market and not require other preservation than satisfactory packing and chilling.

The method of preservation most commonly used for scallops to be stored is freezing. This applies both to Iceland scallops p. 41



Figur 23.

Prinsippskisse for fløtertank.

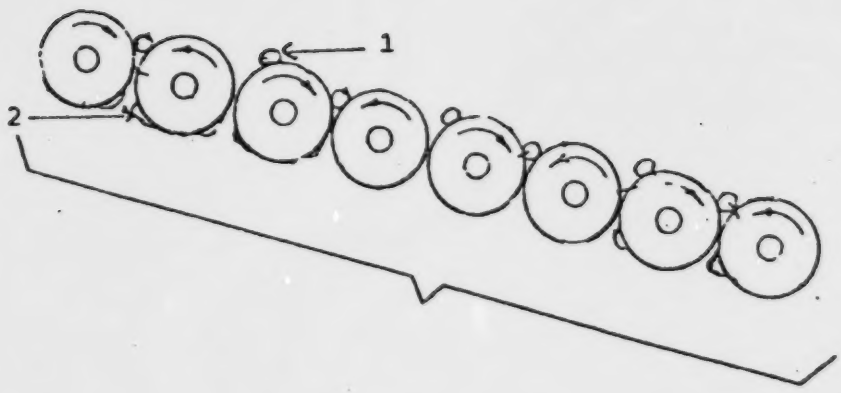
----→ Vatnstråle. Water stream

——→ Transportbånd for rensete bløtdeler. Conveyor belt for cleaned soft tissue.

——→→ Transportbånd for rask. Conveyor belt for debris.

Figure 23.

Sketch in principle for floatation tank.

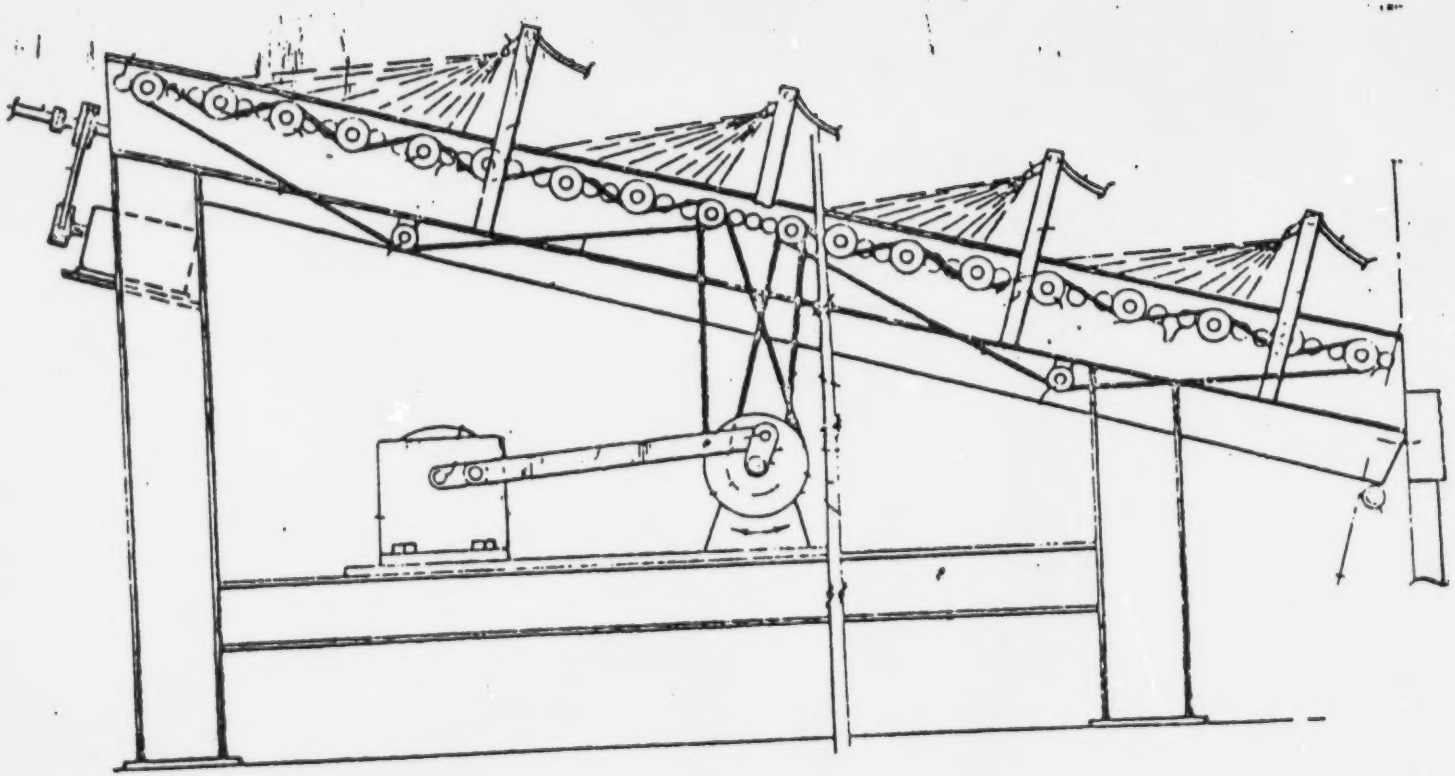


Figur 24. Figure 24. Cleaning of scallop muscle with ocillating rollers.

Rensing av kamskjellmuskel med oscillerende valser.

1) Muskel. Muscle

2) Uønskede bløtdeler. Unwanted soft parts



Figur 25. Figure 25. Cleaning machine for scallops. (After U.S. patent No. 3,562,855)

Rensemaskin for kamskjell.

(Etter US. pat. No. 3.562.855)

and other scallop products. At Sigurd Augustsson Co. all products were frozen in five pound blocks, but a freezing tunnel for single freezing (IQF) was being acquired. In addition, equipment was also to be purchased for breading the scallops. Products of this type are usually more marketable and in addition, a considerable increase in weight can also be achieved (August Sigurdsson, pers. comm.).

However, before packing there should be size and quality grading carried out. Some muscles may be damaged or discolored and should not be packed together with first quality products. Grading into different sizes will, in addition, give better prices since larger scallops are worth more than small ones. It is therefore not desirable that catches contain too many small scallops.

Product Yield

Since the condition of the scallop varies throughout the year (fig. 3), the product yield will vary with the season. The experimental production at H. R. Richardsen in Tromso (October/November 1978) gave the following results (table 5):

Table 5.

Product Yield

Total soft tissue	about 17% of round weight
Muscle and gonad	" 15% " "
Pure muscle	" 12% " "
Glazed muscle	" 13% " "

At the Sigrud Augustsson Co. in Stykkisholmur, it was calculated that product yield of pure muscle must be at least 10% in order to give satisfactory economic viability, and that 13% was the maximum that could be achieved (August Sigurdsson, pers. comm.). p. 42

By-products

Empty shells comprise over 80% of the round weight (table 5). These consist of almost pure lime and can probably be utilized. Any utilization will, however, be dependent on finding markets.

Up to 60% of the soft parts will consists of rims, digestive gland, gills and gonads. If only the muscle is used, these parts will comprise a large quantity of by-products. In Iceland, these parts were not used and were flushed to sea with the rinse water. However, utilization should be possible. Since the protein content is high (Sundet 1979), it would at least be a good salmon feed. This is, however, a poor utilization of good protein, and it should be possible to develop food products of these parts, for example freeze dried soups.

IV. Economics

Marketing

In the discussion so far, only known products have been evaluated. These are sold in established markets, especially the USA, Great Britain, and France. Norway has already established a sales network for frozen fish products in these

markets. Iceland scallops can therefore probably be sold through this network. It is probable that a considerable marketing effort must be mounted to get the products established in competition with other scallop products. To determine how large this effort must be is beyond the scope of the present study.

Iceland scallops would have to be marketed as a new product on the domestic market, but it is assumed that marketing can be carried out through established channels. A marketing effort over longer periods would be required if larger quantities are to be sold.

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Profitability

There are too few data available for calculating the potential economic results from a scallop industry. However, based on the income necessary to make the fishery viable, the costs of manual trial processing at H. Richardsen Ltd. and the costs of mechanized processing in Stykkisholmur, it is possible to set up a summary of variable costs at various processing alternatives.

The first-hand price to fishermen is usually set according to what the processor can pay. So far this has not been possible to estimate, and we will instead attempt to estimate what the price to fishermen must be in order for crew and vessel owner to have satisfactory profitability. It can be based on a typical inshore shrimp trawler with a three-man crew, and distribution 60% to crew and 40% to owner (Anon. 1975). If it is assumed that there are three to four fishing days a week and that the crew

share should be around 400 kroner per day (Anon 1975), the income needed will be as in the example in table 6.

Table 6.

Income necessary per day for a traditional inshore shrimp trawler with a three-man crew.

Crew share, kr. 400 x 3	kr. 1200, -
Owners share	kr. 800, -
Expenses	kr. 250, -
Total	kr. 2250, -

Calculated daily catch: 1500 kg (page 20)

Raw material price needed: kr. 2250.00/1500 = kr. 1.50 per kg.

Processing costs.

In manual processing trials at H. Richardsen Ltd., the variable costs have been calculated. Based on a raw material price of kr. 1.50 per kg, the following calculations can be made for variable costs in the production of pure scallop muscle:

Table 7.

Variable production costs per kg. muscle with manual production. p.41

Raw material costs (12% yield)	kr. 12.50
Variable labor costs (incl. social costs)	" 23.50
Other variable costs (energy costs, etc)	" 2.00
Total variable costs	kr. 37.50

Calculation of fixed costs will depend on if it is necessary to invest in new facilities or if excess capacity in

existing plants can be utilized. The product price must be over 40 kr/kg in order to achieve positive contribution coverage when considering marketing and freight costs as variable costs.

At the Sigurd Augustsson Co. plant, which had a completely automated production line, about 40 tonnes scallops round weight were processed per day. With a product yield of 12% this means 4800 kg cleaned muscle per day. The plant had 60 employees for processing, inspection and packaging. If Norwegian prices are used for a calculation like this, it will result in the following calculation for variable costs per kg finished product.

Table 8.
Variable production costs per kg cleaned muscle for mechanized production.

Raw material costs (12% yield)	kr. 12.50
Variable labor costs (incl. social costs)	" 3.50
Other variable costs(energy costs, etc.)	" 2.50
Sum variable costs	kr. 18,50

If the selling price is kr. 40.00 per kg cleaned muscle, the contribution will be ca. 20 kroner per kg , when marketing and freight costs are added. If the calculations for possible yield from the Balsfjord Grounds are correct, this area alone could have a total contribution of about one million kroner from such production.

Pure muscle of best quality can obtain ca. kr. 50 per kg on the American market (August Sigurdsson, pers. comm.). For other product types, and on other markets, the prices vary

from kr. 30 per kg and up (H.Richardsen, per. comm.). p. 45

Discussion

Richer (1977) assumes that a fishery on a stock results in increased growth by thinning. If this is to be the case, the natural mortality must either be reduced or the recruitment and/or individual growth increased. In a fishery on the Iceland Scallop ground in Balsfjord, individual growth will not increase because the nutrient supply is not limited (page 9). However, one can count on natural mortality being reduced because fishing mortality is being introduced instead of natural mortality.

Quantitative samples from the ground at Berg show that even if the size of the individual year classes varies, there have not been significant changes in the density of this population in total from 1971 and up to today. The density at Berg has in this period been ca. 70 scallops per m^2 (Vahl 1979b). If the density is reduced it will after some time without fishing reach the same level as before because immigration remains the same, while emigration remains low until the original density is re-established (Vahl and Claussen 1979). A fishery will therefore, by reducing the density, give an increased immigration to the exploited area. This hypothesis is supported by experiences from Iceland (page 10). However, one does not have any knowledge of how a fishery would affect the Balsfjord ground in total.

Iceland scallops become sexually mature at three to five years of age and have a maximum age of about 20 years (Vahl 1979a). There are therefore many sexually mature year classes present on the Balsfjord grounds. If the fishery

takes only scallops seven years old or older (shell diameter above 65 mm), the spawning potential will be reduced by 15-20%. Yearly recruitment is on the average 12 scallops per m^2 (Vahl 1979b). Since about 75 million eggs per m^2 are spawned annually, this means that 0.00015 per mille of all eggs spawned at Berg will grow up as recruits. The probability that an egg should be able to survive is thereby so low that a reduction in spawning of 15-20% probably will not be noticeable. One can therefore assume that recruitment is not threatened if only scallops larger than 65 mm are being caught. With the exploitation pattern proposed, the population should not be overexploited (fig. 4). Assuming that the scallops that avoid the rake are not injured, in practice this will mean that an area can be raked clean of scallops over the minimum size without the ability to re-produce being reduced. p.46

A long-term yield of between 500 and 1000 tonnes round weight per year from the Balsfjord grounds can in the first instance seem to be very high. However, it must be considered that Iceland scallops feed directly on phytoplankton and therefore utilize the primary production better than for example cod that live higher up in the food chain. Whether it will be possible in practice to harvest this long term yield, cannot be answered before more information from actual harvesting is available. We have today no knowledge of how a fishery will affect Iceland scallops that are not caught in the rake or if all scallops above the minimum size will be accessible to be caught.

Even if the quantity, for example, is only half of that calculated as theoretically possible, it will still be so large

that the grounds can be utilized commercially. Two shrimp trawlers will in the period August-December be able to fish ca. 250 tonnes round scallops. The product value of this quantity would be ca. 1 million kroner, and if processing is manual, 25 to 30 people could be employed.

Few data are available on which to estimate the yield from other grounds. Earlier studies (Wiborg 1962 and 1963) give reason to believe that the concentrations along the coast can be exploited. This applies primarily to the ground in Porsanger, and since a considerable quantity was taken in a small area in Kvaenangen (page 3), it is assumed that it is also possible to fish the smaller concentrations.

The largest grounds in Norwegian waters are, however, found around Bear Island and Spitzbergen. If there are densities there that can give a basis for satisfactory catch rates with the gear technology available today, there seems to be opportunities for considerable catches. Wiborg (1970) estimates that around Bear Island there are grounds with an area of ca. 480 km^2 where the density of scallops is relatively high. Even if these densities should be considerably lower than on the Balsfjord ground (8-10 km^2), there could still be many times as many scallops at Bear Island.

However, it seems to be evident that the catch rates that were earlier achieved on these grounds (Wiborg 1970) are not satisfactory for commercial utilization. It must therefore be clarified whether newer equipment can give satisfactory catch rates.

On the best grounds along the coast, satisfactory results can also be achieved with the equipment used during our

experiments (page 16). It would, however, be necessary to find better rake equipment, if fishing is to be carried out on grounds less suited for raking , which do not have such high densities as the Berg ground.

Fishing for Iceland scallops could be carried out with the existing fleet. A shrimp trawler can easily be converted to carry out scallop dragging in the fjords. The adjustments necessary will be relatively small and chiefly be limited to the purchase of gear. Shrimp trawlers of all sizes will be able to pursue the fishery, but since space requirements for sorting and holding the catch are relatively large, the vessels should be at least 45 feet. Due to the labor requirements during sorting, the crew should be at least three persons in order to utilize the rake capacity.

With the gear and the arrangement used during our trials, it seems to be a pre-requisite that the raw material prices are a minimum of kr. 1.50 per kg. With a better organization and/or by using better gear types, a satisfactory profitability can also possibly be achieved with lower raw material prices.

Iceland scallops in the round are voluminous and have a limited keeping time. If the concentrations at Bear Island are to be utilized, it will therefore be necessary to develop techniques for processing the scallops onboard. If it is possible to double-freeze Iceland scallops, the best solution would probably be to shuck and freeze the scallops onboard and take them ashore for further processing. This would also be a good solution for the industry ashore, since scallops can then contribute to maintaining employment in slack periods.

Manual processing of Iceland scallops is very labor-intensive and therefore expensive in Norway (table 7). Manual shucking and cleaning would therefore only be practical for small quantities. The production volume does not have to be high, before it would pay to take in use technical equipment in one or more stages of the production. Firstly, the shucking process should be mechanized. The equipment needed for this is relatively simple (page 35), and the variable costs can be reduced considerably with small investments. Shucked scallops are also a product that is marketable with little extra processing. Even if this product does not give the highest prices, such production could be a good alternative for small quantities. p. 48

If pure scallop muscle is to be produced, almost 20 kroner per kg in variable costs can be saved by using mechanized processing instead of manual (table 8 and 9). The volume to be processed does not therefore have to be high before an investment in equipment for mechanical cleaning is feasible. The Balsfjord ground would probably yield a quantity of 50 tons of pure muscle per year, and one would in that case be able to save around a million kroner yearly in variable costs.

The whole processing line at Sigurd Augustsson Co. was estimated to have a value of about two million Norwegian kroner (not including building, wharf, freezing equipment, etc.). The amount could not be confirmed exactly since a large part of the equipment was designed and built locally. It is, however, possible that the processing to pure muscle can be made more efficient with smaller investments, for example if an ordinary shrimp peeling machine can be rebuilt for cleaning Iceland scallops.

Conclusion

With the knowledge we have today of possible market prices, it does not seem to be possible to achieve a profit with manual processing of Iceland scallops. The variable costs are very high, and it would probably be difficult to achieve a sufficient contribution to also cover the fixed costs. Production of Iceland scallops would therefore only be possible for plants that have the necessary capital equipment and free capacity. In a situation like that, processing would be justifiable as long as all variable costs are covered. The first trial production at H. Richardson Ltd. gives reason to believe that this is possible, and there is also reason to believe that the variable costs can be lowered as experience is being gained. p. 49

It cannot be considered justifiable at this time to invest in extensive technical equipment for the processing of Iceland scallops. The raw material supply is still uncertain, and it is also not advisable to gear up for a processing plant that will require regular raw material supplies the whole year.

It can therefore be assumed that utilization of Iceland scallops from coastal areas is only practical as an alternative activity at established plants. Such processing would first and foremost have a value in that it could keep activity and employment going in periods when there is otherwise low activity. It would also be of value if it could increase the contribution margin annually for the enterprise.

The scallop resources in Norwegian waters are probably large, but they are today little or not utilized. It may

therefore prove to be true that a fishery of Iceland scallop along the coast has its greatest value in that experience can be gained with a view to future commercial exploitation of other shell species.

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